Essays on International Capital Flows

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Chapter 1

A Decomposition of International Capital Flows

Abstract

We propose a method to break down capital flows into portfolio growth and portfolio reallocation components and apply it to data on US equity and bond outflows. The decomposition is part of an integrated approach that decomposes purchases of any asset into portfolio growth and reallocation components. US equity and bond outflows depend not just on portfolio growth and the reallocation between US and foreign equity and bonds, but also on reallocation decision higher up on the decision tree. This includes reallocation between portfolio and non-portfolio assets and between equity and bonds. We also consider the decomposition of US equity and bond outflows to individual foreign countries. The data shed light on the importance of the various components as drivers of capital flows in both the short and long run.

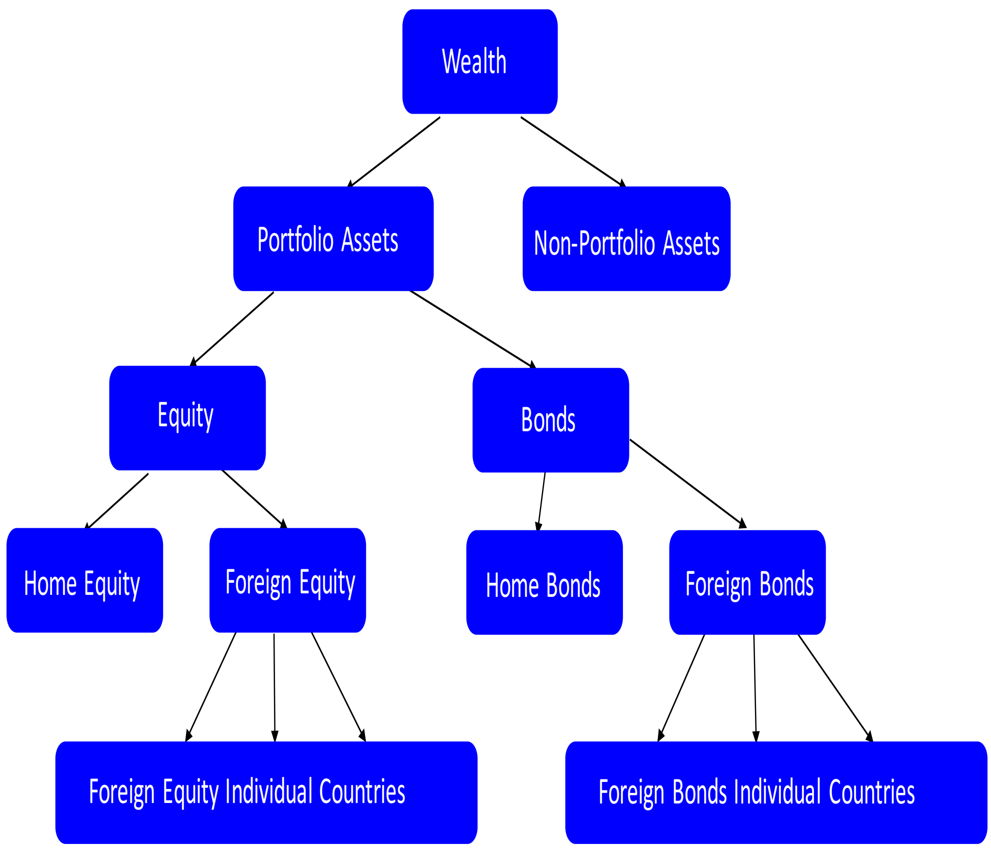
1.1 Introduction

International capital flows play an increasingly important role in national and global business cycles. Understanding what drives capital flows is therefore a key research area. One way to get a better understanding is to decompose capital flows into portfolio growth and reallocation components. Tille and van Wincoop (2010a) show how to do so at a theoretical level, but their approach has not yet been implemented empirically. The portfolio growth component for capital outflows is associated with changes in the overall portfolio. It is equal to saving times the fraction invested abroad. The portfolio reallocation component of capital outflows is associated with changes in the portfolio share allocated to foreign assets, but only to the extent that this is not the result of valuation effects.

Our objective is to extend and empirically implement the decomposition proposed in Tille and van Wincoop (2010a). This provides new insight into the drivers of capital flows that can guide future theoretical work. We focus on equity and bond outflows from the United States, which we break down into a portfolio growth component and a series of reallocation components. The decomposition we develop goes well beyond that in Tille and van Wincoop (2010a). It is part of an integrated approach to decompose purchases of any asset class into portfolio growth and reallocation components.

The various portfolio reallocation components can be thought of as related to a series of decisions on asset allocation at various nodes of a decision tree, illustrated in Figure 1. At the top of the tree investors need to make a decision how to allocate their wealth between portfolio assets (equity and bonds) and non-portfolio assets (all other assets). Going one step down the decision tree, investors need to decide how to allocate portfolio assets between equity and bonds. One step further down, agents needs to decide how to allocate their equity (or bond) portfolio between domestic and foreign equity (or bonds). At the bottom of the tree we also consider reallocation across different foreign countries.

Figure 1.1: Households Decision Tree



Portfolio reallocation decisions higher up the decision tree affect asset purchases further down. For example, when there is a portfolio shift from bonds to equity, this leads to more equity outflows even when saving (portfolio growth) does not change and the fraction of the equity portfolio allocated to Foreign equity does not change.

We will discuss four decompositions of asset purchases. The first decomposition breaks down portfolio purchases into a portfolio growth component and reallocation between portfolio and non-portfolio assets. The second decomposition breaks down equity (or bond) purchases into the previous two components plus a reallocation component between equity and bonds. The third decomposition breaks down equity (or bond) outflows into the previous three components, plus a reallocation component between Home and Foreign equity (or bonds). The last decomposition breaks down equity (or bond) outflows to individual foreign countries into the previous four components plus a reallocation component between foreign countries.

We do not claim that agents make portfolio decisions in the sequence suggested by Figure 1. Our approach here is atheoretical. There may be shocks to the economy that simultaneously set off multiple reallocation decisions. In a general equilibrium framework this is almost unavoidable. We take no position on what the deeper underlying drivers of the various reallocation components may be. We mainly aim to shed light on the relative importance of the various components, both in the short and long run.

Our approach is applied to quarterly data for the United States from 1994 to 2014. In the third decomposition we consider both U.S. equity and bond outflows. In the fourth decomposition we consider U.S. equity and bond outflows to individual countries. Empirical implementation of these decompositions is facilitated by high quality monthly data on U.S. external equity and bond holdings in various countries from Bertaut and Tryon (2007), who correct for inconsistencies between reported TIC survey position and flow data. The data have recently been used by Curcuru et al. (2008, 2010) and Curcuru et al. (2011) to analyze return differentials and the relationship between portfolio reallocations and past returns. We extend the approach in Bertaut and Tryon (2007) to a longer sample from 1994 to 2014.

Some related papers are Ahmed et al. (2016), Curcuru et al. (2011) and Guo and Jin (2009). Ahmed et al. (2016) focus on US equity flows to emerging markets, which they decompose into a portfolio growth component and a residual. The latter is the sum of four different reallocation components that we consider in the fourth decomposition. Curcuru et al. (2011) do not consider a complete decomposition of US equity outflows to foreign countries, but focus on a component of these flows that is analogous to what we refer to as the reallocation between different foreign countries.[1] Guo and Jin (2009) decompose changes in the net foreign asset position into a "growth effect" and "composition effect." These are related to what we refer to as portfolio growth and Home-Foreign reallocation, but they are not the same. Changes in the value of asset holdings depend on valuation effects. Our decompositions instead focus on asset purchases. Another difference is that the composition effect, which is related to changes in the ratio of net foreign assets to total wealth, depends on portfolio decisions by both US investors (external assets) and foreign investors (external liabilities). Our focus will be on capital outflows and we therefore take the perspective of U.S. investors.[2]

The paper also connects to a growing literature that emphasizes portfolio al-

[1]This is the fourth reallocation component of the fourth decomposition that we consider. Curcuru et al. (2011) investigate the relationship between this component with past and future relative returns of these countries.

[2]See Tille and van Wincoop (2010b) for a further discussion on treating the ratio of net foreign assets to wealth as a portfolio share.

location decisions as drivers of capital flows in open economy DSGE models with incomplete financial markets, where endogenous time variation in expected returns and risk lead to time variation in portfolio allocation.[3] In Section 5 we will interpret some of our findings in the context of existing theory. We do not develop a new model here. The empirical results are meant to guide and stimulate future theoretical work.

The remainder of the paper is organized as follows. Section 2 discusses the decomposition of portfolio flows. Section 3 discusses the data used to apply the decomposition to US portfolio flows. Section 4 discusses the empirical findings. Section 5 discusses the connection of our findings to related theoretical literature. Section 6 concludes.

1.2 Decomposition of Portfolio Flows

In this section we discuss four decompositions of portfolio flows. We will focus on the same four decompositions in the empirical results in Section 4. Each time a new reallocation component is added as we go a step further down the decision tree. This is a logical approach as decisions further up the decision tree will have an impact on capital flows near the bottom of the decision tree. It also illustrates how our decomposition of capital flows is integrated into a broader decomposition of financial flows.

[3] Examples are Bacchetta and van Wincoop (2017), Davis and van Wincoop (2018), Devereux and Sutherland (2007, 2010), Didier and Lowenkron (2012), Evans and Hnatkovska (2014), Gabaix and Maggiori (2015), Hnatkovska (2010) and Tille and van Wincoop (2010a,b, 2014).

1.2.1 First Decomposition

Let the wealth of the Home country be

$$A_t = \sum_{i=1}^{N} X_t^i Q_t^i \tag{1.1}$$

Here the superscript i denotes an asset class, X_t^i is the quantity held of asset i and Q_t^i is the price of asset i. The value of wealth next period is

$$A_{t+1} = \sum_{i=1}^{N} X_t^i Q_{t+1}^i + S_{t+1} \tag{1.2}$$

Here S_{t+1} is saving, which equals asset plus non-asset income minus consumption and consumption of fixed capital.

Denoting $\Delta x_{t+1} = x_{t+1} - x_t$, we have

$$\Delta A_{t+1} = \sum_{i=1}^{N} k_t^i A_t \frac{\Delta Q_{t+1}^i}{Q_t^i} + S_{t+1} \tag{1.3}$$

where

$$k_t^i = \frac{X_t^i Q_t^i}{A_t} \tag{1.4}$$

is the portfolio share invested in asset i.

Some comments about notation are in order. We will use superscripts to denote an asset class. Examples are $i = p$ for portfolio assets, $i = np$ for non-portfolio assets, $i = e$ for equity, $i = b$ for bonds, $i = e, F$ for Foreign equity and $i = e, F, n$ for Foreign equity of country n. So $k_t^{e,F,n}$ is the portfolio share allocated to Foreign equity of country n. We also define portfolio shares within an asset class. For example, the portfolio share allocated to equity as a fraction of all portfolio assets (bonds plus equity) is denoted $k_t^{e|p}$. Analogously, the fraction of the equity portfolio allocated to Foreign equity is $k_t^{F|e}$ and the fraction of the Foreign equity portfolio allocated to country n is $k_t^{n|e,F}$.

In the first decomposition we consider the allocation between portfolio and non-portfolio assets. Since these two asset classes make up all assets, we can write (1.3) as

$$\Delta A_{t+1} = k_t^p A_t \frac{\Delta Q_{t+1}^p}{Q_t^p} + \left(1 - k_t^p\right) A_t \frac{\Delta Q_{t+1}^{np}}{Q_t^{np}} + S_{t+1} \tag{1.5}$$

Linearizing $k_t^p A_t = Q_t^p X_t^p$, we have

$$k_t^p \Delta A_{t+1} + A_t \Delta k_{t+1}^p = Q_t^p \Delta X_{t+1}^p + X_t^p \Delta Q_{t+1}^p \tag{1.6}$$

This is based on linearization around the time t values of the variables, which we will do throughout. Combining the last two equations, we have an expression for the purchases of portfolio assets:

$$Q_t^p \Delta X_{t+1}^p = A_t \Delta k_{t+1}^p - A_t k_t^p (1 - k_t^p) \left[\frac{\Delta Q_{t+1}^p}{Q_t^p} - \frac{\Delta Q_{t+1}^{np}}{Q_t^{np}} \right] + k_t^p S_{t+1} \tag{1.7}$$

An increase in k_t^p does not necessarily imply increased purchases of portfolio assets as the increase can also be due to valuation effects. It is therefore useful to define passive portfolio share changes that are due to asset price changes, holding quantities unchanged. We have

$$k_t^p = \frac{X_t^p Q_t^p}{X_t^p Q_t^p + X_t^{np} Q_t^{np}} \tag{1.8}$$

Denote $\Delta \tilde{k}_{t+1}^p$ as the change in this portfolio share due exclusively to valuation effects.

Differentiating (1.8) with respect to the prices, holding the quantities fixed, we have

$$\Delta\tilde{k}^p_{t+1} = k^p_t(1-k^p_t)\left(\frac{\Delta Q^p_{t+1}}{Q^p_t} - \frac{\Delta Q^{np}_{t+1}}{Q^{np}_t}\right) \tag{1.9}$$

(1.7) can then be written as

$$\begin{aligned} Q^p_t \Delta X^p_{t+1} &= k^p_t S_{t+1} + \\ & k^p_t A_t \frac{\Delta k^p_{t+1} - \Delta\tilde{k}^p_{t+1}}{k^p_t} \end{aligned} \tag{1.10}$$

This decomposes purchases of portfolio assets into two components. The first term is the portfolio growth term. It multiplies household saving with the portfolio share allocated to portfolio assets. The second term is a portfolio reallocation term, which captures reallocation between portfolio and non-portfolio assets. It is associated with the change in the portfolio share allocated to portfolio assets to the extent that this is not due to valuation effects.

1.2.2 Second Decomposition

We now go one step further down the decision tree and consider the breakdown of equity purchases. There is an analogous decomposition for bond purchases.

Using that $k^e_t = k^p_t k^{e|p}_t$, we have

$$Q^e_t X^e_t = k^p_t k^{e|p}_t A_t \tag{1.11}$$

Differentiating this, substituting the expression for ΔA_{t+1} in (1.5), and using

$$\frac{\Delta Q^p_{t+1}}{Q^p_t} = k^{e|p}_t \frac{\Delta Q^e_{t+1}}{Q^e_t} + (1 - k^{e|p}_t)\frac{\Delta Q^b_{t+1}}{Q^b_t} \tag{1.12}$$

after a bit of algebra equity purchases can be written as

$$\begin{aligned} Q^e_t \Delta X^e_{t+1} &= k^e_t S_{t+1} + \\ &\quad k^e_t A_t \frac{\Delta k^p_{t+1} - \Delta \tilde{k}^p_{t+1}}{k^p_t} + \\ &\quad k^e_t A_t \frac{\Delta k^{e|p}_{t+1} - \Delta \tilde{k}^{e|p}_{t+1}}{k^{e|p}_t} \end{aligned} \tag{1.13}$$

where

$$\Delta \tilde{k}^{e|p}_{t+1} = k^{e|p}_t (1 - k^{e|p}_t) \left(\frac{\Delta Q^e_{t+1}}{Q^e_t} - \frac{\Delta Q^b_{t+1}}{Q^b_t} \right) \tag{1.14}$$

The last equation shows the change in passive portfolio share allocated to equity within portfolio assets, which is due to a change in the relative price of equity to bonds.

(1.13) shows the decomposition of equity purchases into three components. The first is the portfolio growth component, which is equal to the portfolio share allocated to equity times saving. The last two terms are reallocation terms. The first one (second line) is associated with the reallocation between portfolio and non-portfolio assets, which also appeared in the first decomposition. A shift towards portfolio assets leads to increased purchases of both equity and bonds when holding the allocation between them constant. The second reallocation term is between equity and bonds. An increase in the active portfolio share $k^{e|p}_t$ allocated to equity within portfolio assets implies a shift from bonds to equity that implies increased equity purchases. We again subtract changes in the portfolio share that result from valuation effects.

1.2.3 Third Decomposition

Going one further step down the decision tree, we arrive at capital flows. We decompose the purchases of Foreign equity and bonds. Agents need to decide the allocation of their equity and bond portfolios between Home and Foreign assets. We again illustrate the decomposition for equity, with an analogous result applying to bonds.

Using that

$$k_t^{e,F} = k_t^p k_t^{e|p} k_t^{F|e} \tag{1.15}$$

we have

$$Q_t^{e,F} X_t^{e,F} = k_t^p k_t^{e|p} k_t^{F|e} A_t \tag{1.16}$$

Differentiating this, substituting the expression for ΔA_{t+1} in (1.5), and using

$$\frac{\Delta Q_{t+1}^e}{Q_t^e} = k_t^{F|e} \frac{\Delta Q_{t+1}^{e,F}}{Q_t^{e,F}} + (1 - k_t^{F|e}) \frac{\Delta Q_{t+1}^{e,H}}{Q_t^{e,H}} \tag{1.17}$$

after a bit of algebra equity outflows $Q_t^{e,F} \Delta X_{t+1}^{e,F}$ can be written as

$$\begin{aligned} Equity\,Outflows_{t+1} = \; & k_t^{e,F} S_{t+1} + \\ & k_t^{e,F} A_t \frac{\Delta k_{t+1}^p - \Delta \tilde{k}_{t+1}^p}{k_t^p} + \\ & k_t^{e,F} A_t \frac{\Delta k_{t+1}^{e|p} - \Delta \tilde{k}_{t+1}^{e|p}}{k_t^{e|p}} + \\ & k_t^{e,F} A_t \frac{\Delta k_{t+1}^{F|e} - \Delta \tilde{k}_{t+1}^{F|e}}{k_t^{F|e}} \end{aligned} \tag{1.18}$$

where

$$\Delta\tilde{k}_{t+1}^{F|e} = k_t^{F|e}(1 - k_t^{F|e})\left(\frac{\Delta Q_{t+1}^{e,F}}{Q_t^{e,F}} - \frac{\Delta Q_{t+1}^{e,H}}{Q_t^{e,H}}\right) \tag{1.19}$$

The last equation shows the change in passive portfolio share allocated to Foreign equity within the equity portfolio, which is due to a change in the relative price of Foreign to Home equity.

(1.18) shows the decomposition of equity outflows into four components. The first is the portfolio growth component, which is equal to the portfolio share allocated to Foreign equity times saving. The last three terms are reallocation terms. The first one (second line) is associated with the reallocation between portfolio and non-portfolio assets (from first decomposition). The second reallocation is between equity and bonds (from second decomposition). The third portfolio reallocation term is new and captures the reallocation between Foreign equity and Home equity. An increase in the portfolio share $k_t^{F|e}$ allocated to Foreign equity within the equity portfolio implies a shift towards Foreign equity that leads to increased equity outflows. We again subtract changes in the portfolio share that result from valuation effects.

1.2.4 Fourth Decomposition

We finally go down to the bottom of the decision tree, which involves the decision how to allocate the Foreign equity (or Foreign bond) portfolio across the different foreign countries. This leads to a decomposition of equity or bond flows to a particular foreign country into a portfolio growth component and four portfolio reallocation components. We again illustrate this for equity.

Using that

$$k_t^{e,F,n} = k_t^p k_t^{e|p} k_t^{F|e} k_t^{n|e,F} \tag{1.20}$$

we have

$$Q_t^{e,F,n} X_t^{e,F,n} = k_t^p k_t^{e|p} k_t^{F|e} k_t^{n|e,F} A_t \tag{1.21}$$

Differentiating this, substituting the expression for ΔA_{t+1} in (1.5), and using

$$\frac{\Delta Q_{t+1}^{e,F}}{Q_t^{e,F}} = \sum_n k_t^{n|e,F} \frac{\Delta Q_{t+1}^{e,F,n}}{Q_t^{e,F,n}} \tag{1.22}$$

after a bit of algebra equity outflows to country n, $Q_t^{e,F,n} \Delta X_{t+1}^{e,F,n}$ can be written as

$$\begin{aligned} Equity\ Outflows_{t+1}^n \quad = \quad & k_t^{e,F,n} S_{t+1} + \\ & k_t^{e,F,n} A_t \frac{\Delta k_{t+1}^p - \Delta \tilde{k}_{t+1}^p}{k_t^p} + \\ & k_t^{e,F,n} A_t \frac{\Delta k_{t+1}^{e|p} - \Delta \tilde{k}_{t+1}^{e|p}}{k_t^{e|p}} + \\ & k_t^{e,F,n} A_t \frac{\Delta k_{t+1}^{F|e} - \Delta \tilde{k}_{t+1}^{F|e}}{k_t^{F|e}} \\ & k_t^{e,F,n} A_t \frac{\Delta k_{t+1}^{n|e,F} - \Delta \tilde{k}_{t+1}^{n|e,F,n}}{k_t^{n|e,F}} \end{aligned} \tag{1.23}$$

where

$$\Delta \tilde{k}_{t+1}^{n|e,F} = k_t^{n|e,F} \left(\frac{\Delta Q_{t+1}^{e,F,n}}{Q_t^{e,F,n}} - \frac{\Delta Q_{t+1}^{e,F}}{Q_t^{e,F}} \right) \tag{1.24}$$

The last equation shows the change in passive portfolio share allocated to equity in foreign country n within the equity portfolio allocated to all foreign countries, which is due to a change in the relative price of country n equity to all Foreign equity.

(1.23) shows the decomposition of equity outflows to country n into five components. The first is the portfolio growth component, which is equal to the portfolio share allocated to country n equity times saving. The last four terms are the reallocation components. The first three of these are familiar from the first three decompositions, capturing respectively the reallocation between portfolio and non-portfolio equity, between equity and bonds and between Home and Foreign equity. The last reallocation component is new, reflecting equity flows to country n associated with a reallocation of the Foreign equity portfolio towards country n. An increase in the portfolio share $k_t^{n|e,F}$ allocated to equity of foreign country n within the Foreign equity portfolio, after subtracting valuation effects, implies increased equity outflows to country n.

Ahmed et al. (2016) decompose US equity outflows to emerging markets into a portfolio growth component and a residual. When n is the sum of emerging markets, the residual is equal to the sum of the four reallocation components for that n. It therefore reflects a variety of different types of reallocation. Curcuru et al. (2011) consider a portfolio reallocation term that corresponds to the fourth reallocation component in this last decomposition, representing the reallocation between foreign countries. They consider how this component is related to past and future relative returns.

1.3 Data

In order to implement the decompositions, we need data on purchases, returns and portfolio shares of various asset classes, as well as net private savings and household wealth. The asset classes correspond to the four decompositions in the previous section: aggregate of portfolio assets; equity and bonds; Foreign equity and bonds; equity and bonds of individual foreign countries. We will use monthly data from April, 1994 to December, 2014. As we will discuss below, we aggregate to the quarterly frequency as some of the data are only available quarterly. We first describe the equity and bond outflow data as they pose the biggest challenge. After that we discuss data on asset returns, portfolio shares and purchases of all asset classes.

Our starting point for the capital outflow data is the dataset from Bertaut and Tryon (2007) on bilateral positions in equity and bonds. We first describe the approach followed by Bertaut and Tryon (2007) and then discuss how we use it to obtain capital outflow data. These take the form of purchases of foreign equity and bonds, both in aggregate and of individual foreign countries.[4]

1.3.1 Bertaut and Tryon (2007)

Bertaut and Tryon (2007) (henceforth BT) report monthly estimates of U.S. cross-border equity and bond positions by combining high-quality but low frequency TIC (Treasury International Capital) survey positions with high frequency TIC S flow data.[5] TIC periodic position surveys provide the most detailed and accurate information on bilateral securities holdings. However, these surveys are conducted relatively infrequently. They became annual surveys from 2004. Before that, surveys were 2-4 years apart.[6] The flow data are monthly. The change in the position from one month to the next is equal to the flow plus valuation changes. Therefore data on the flows and valuation changes can be used to compute the positions for the months between surveys. A problem that arises though is that following this approach from one survey date to the next leads to inconsistencies with the survey position data.

To be precise, define p_t^n as the naive position (defined below) and p_t^s as the survey

[4] We thank Frank Warnock for helping us understand the international position and flow data.

[5] The BT data are available at http://www.federalreserve.gov/pubs/ifdp/2007/910/ticdata.zip.

[6] The surveys of claims before 2004 took place 3/31/1994, 12/31/1997, 12/31/2001 and 12/31/2003.

position. Since we only use data on external claims, these refer to the value of U.S. holdings of equity or bonds in individual foreign countries or the aggregate of all foreign countries. The naive position starts from a survey date, at which time it is set equal to the survey position, and then accumulates according to

$$p^n_{t+1} = p^n_t + flow_{t+1} + r_{t+1}p^n_t \tag{1.25}$$

Here $flow_{t+1}$ is the transaction flow (purchases of foreign equity or bonds) from TIC S and r_{t+1} is the return (relative price change) during this month that gives rise to valuation changes.

By the time we reach the next survey date, p^n_t tends to deviate from p^s_t. Since the survey data are very high quality, this happens because of either errors in the flow data or valuation data. BT discuss many of the problems with the flow data. One issue is "transaction bias" in that transactions are recorded according to the first cross-border counterparty (often broker-dealers) as opposed to the actual buyer or seller. This leads to a bias towards financial centers. The transaction data also miss flows that do not pass through standard TIC reporting channels, such as repayments of principal on asset-backed securities or acquisition of equity through merger-related stock swaps or re-incorporations.

One immediate adjustment that BT make is to add stock swap data to the TIC flow data. But this leaves other errors in the flow and valuation data that still cause a "gap" between p^n_t and p^s_t during the next survey date. BT then develop a procedure to allocate this gap to the individual months.[7] Their estimate of the position is then

$$p_t = p_t^n + gap_t \tag{1.26}$$

where gap_t is the gap that is allocated to month t to make the monthly position data consistent with the less frequent survey data.

1.3.2 Capital Flows

BT take no position on whether the gap is a result of errors in the flow data or the valuation data. As a result, they do not report a capital flow series. The contribution of their work is rather the creation of a monthly position series p_t as described above, which can be used for example to compute portfolio shares in individual foreign countries in a way that is less subject to problems such as the "transaction bias."

The first step in the approach we take is to apply the BT method to our entire sample of April, 1994, through December, 2014, to obtain monthly position data. The BT data are available online through December 2011. We therefore extend the BT method to a couple of years beyond their sample. The second step is to compute capital flow data. For this we take the approach advocated in Curcuru et al. (2011) to compute "restated capital flows."[8] Flows are computed as

$$flows_{t+1} = p_{t+1} - p_t - r_{t+1}p_t \tag{1.27}$$

In other words, flows are equal to the change in the estimated position, minus valu-

[7] See the Appendix of BT for details.

[8] See Warnock and Warnock (2009) for a related approach. We thank Frank Warnock for explaining to us in detail the approach used to compute restated flows in Curcuru et al.(2011).

ation effects, where the latter is the return times the previous position. We discuss the return series below. This essentially attributes the gap to the flows as the return data are considered to be reasonably accurate.

A couple of comments are in order about the data after 2011. Bertaut and Judson (2011) (from hereon BJ) extend the position series from BT to data beyond 2011. They use a different approach, using monthly TIC SLT survey data that were collected in response to dissatisfaction with delays in accurate position data during the global financial crisis. TIC introduced a new securities reporting form, the TIC SLT form, to address the shortcomings of TIC position surveys and TIC S flow data. It provides much more timely and frequent reports than TIC position surveys. Compared to TIC S flow data, TIC SLT provides information on the market value of actual holdings rather than flows. BJ adjust the monthly TIC SLT position data a bit to the extent that there is a deviation with the annual survey position, but overall the TIC SLT data are quite accurate.

Like BT, BJ do not report capital flow data. One could take their monthly position data and subtract monthly valuation changes, $r_{t+1}p_t$, to compute flows. This may seem to be analogous to the way we compute restated flows in (1.27), but it is not. In fact, it leads to a capital flow series that is excessively volatile at times. The problem is that the return data have some measurement problems as well, as discussed in BJ. When combining accurate position data with errors in the valuation changes, these valuation errors translate directly into errors in the estimated flows. This is much less the case in the approach we follow based on the BT estimated positions. If, for example, the return for a particular month is overstated, this will overstate the naive position as seen in (1.25), but then the same error is subtracted when computing the flows as in (1.27). It is only the average return measurement error between annual surveys that can lead to errors in our flow measure as it contributes to the gap that is allocated to individual months. These average return errors over a year are much smaller than the monthly errors. We therefore do not use the BJ position data and instead apply the BT method to our entire sample to compute position data and compute the capital flows as in Curcuru et al.(2011).[9]

1.3.3 Asset Returns, Portfolio Purchases and Portfolio Shares

So far we have discussed the purchases of assets of one particular asset class (foreign bonds and equity). To implement the decompositions we also need data on purchases of the broader asset classes as well as data on asset returns and portfolio shares for all asset classes. We turn to this now.

Portfolio Shares

We need data on 4 portfolio shares: the share k_t^p allocated to portfolio assets, the share $k_t^{e|p}$ of the portfolio assets that is allocated to equity, the share $k_t^{F|e}$ of the equity portfolio that is allocated to Foreign equity and the share $k_t^{n|e,F}$ of the Foreign equity portfolio that is allocated to a specific foreign country n. For the latter two we also need analogous portfolio shares for bonds.

We start with total wealth A_t, which is obtained from the Financial Accounts of the United States, measuring the net worth of households and nonprofit organizations.[10] We subtract consumer durables assets (line 8). This is because we use the

[9]In addition, we have also computed all results reported in Section 4 when the sample ends in December, 2011, using the BT position data that are available online without extending their sample further. We finds that this makes virtually no difference for the results.

[10]This is equal to line 1 of Table B.100 of the Financial Accounts (total assets), minus line 31 (liabilities).

NIPA measure of net private saving for S_t from the BEA, which subtracts expenditures on consumer durables to compute saving. This is the only difference between the NIPA definition of saving and the definition in the Flow of Funds data. The change in A_t is then equal to saving plus the change due to valuation effects. A rough description of A_t is portfolio assets plus real estate, plus deposits at financial institutions minus borrowing from financial institutions.

To compute k_t^p we first need to compute the total equity and bond portfolio of the United States. For the equity market we take the total U.S. equity market capitalization plus external equity assets minus external equity liabilities. U.S. equity market capitalization data are from the Financial Accounts of the United States.[11] We then use the BT and BJ position data described above to add external equity holdings and subtract external equity liabilities. For bond market capitalization we use BIS data, aggregating bonds issued by the general government, financial corporations and non-financial corporations.[12] We then use the BT and BJ position data to add external bond holdings and subtract external bond liabilities. k_t^p is then computed as the sum of U.S. equity and bond holdings, divided by A_t.

The portfolio share $k_t^{e|p}$ is simply the ratio of equity holdings described above and the sum of equity plus bond holdings. The portfolio share $k_t^{F|e}$ is equal to the total external equity holdings from BT divided by total equity holdings. Finally, for $k_t^{n|e,F}$ we divide external equity holdings in country n from BT by total foreign equity holdings from BT. These portfolio shares are analogously computed for bonds.

[11] We obtain the data form Table B.1, market value of domestic corporations.

[12] See BIS, Debt Securities Statistics.

Asset Returns

We need data on portfolio returns Q^p_{t+1}/Q^p_t, equity returns Q^e_{t+1}/Q^e_t, bond returns, Foreign and Home equity returns $Q^{e,F}_{t+1}/Q^{e,F}_t$ and $Q^{e,H}_{t+1}/Q^{e,H}_t$, Foreign and Home bond returns, equity returns $Q^{e,F,n}_{t+1}/Q^{e,F,n}_t$ for foreign country n and bond returns for foreign country n.[13]

It is easiest to start with the returns on foreign equity and bonds. For this we use estimates of the foreign equity and bond returns from BT and BJ. While they do not report their return series, it can easily be extracted from their reported data. BJ report the valuation changes, from which the return is simply computed by dividing by their position series. We use this from January 2012 to the end of the sample. Prior to that we use the valuation changes reported by BT. Their reported valuation changes apply to the naive position, so $r_{t+1}p^n_t$. We therefore divide by the naive position to get the return series. We adopt this approach for both individual foreign countries and the aggregate of foreign countries.[14]

We compute Q^e_{t+1}/Q^e_t as a weighted average of U.S. and Foreign equity returns as in (1.17) with the portfolio share as discussed above. The Foreign equity return is described above. For the Home (U.S.) equity return we use the S&P stock return. Q^b_{t+1}/Q^b_t is computed analogously, where we use the Barclays Capital Aggregate Bond Index to compute the U.S. bond return.[15] Finally, Q^p_{t+1}/Q^p_t is computed as in (1.12),

[13] We do not need data on the return of non-portfolio assets. In all decompositions we treat the reallocation between portfolio and non-portfolio assets as a residual, after computing the portfolio growth component and other reallocation components.

[14] The latter is the All Countries and IROs row in BT, code 99996. It should be noted that for equity these returns are highly correlated with the MSCI. The average correlation in our sample is 0.9968.

[15] The latter includes Treasury securities, government agency bonds, mortgage-backed bonds, corporate bonds and a small amount of foreign bonds traded in US. Before November, 2008, it was called the Lehman Aggregate Bond Index.

using the portfolio share $k_t^{e|p}$ and equity and bond returns described above.

Asset Purchases

We finally need data on purchases of various assets classes. We have already discussed Foreign equity and bond purchases, both the aggregate and that of individual countries. Total equity purchases, which includes U.S. plus foreign equity, are computed as the change in the nominal value of equity holdings minus the net portfolio return $[Q_{t+1}^e/Q_t^e] - 1$ times equity holdings at time t. Bond purchases are computed analogously, while portfolio purchases are equal to the sum of equity and bond purchases.

1.3.4 Frequency of the Data

Some of the data are available at the monthly frequency, such as the equity and bond outflows. But we aggregate to the quarterly frequency as some of the data are only available quarterly (net private saving, total wealth and bond market capitalization). We compute changes in portfolio shares and asset prices from the end of the previous quarter to the end of the current quarter.

1.4 Results

We present the results in the form of a series of graphs and tables, with key features summarized in a set of four Empirical Findings. The tables and figures shed light on the importance of the various components of the four decompositions in the short and long run.

We will also compare the reallocation components to what they would have been under perfect rebalancing. The latter assumes that agents wish to keep their portfolio shares unchanged. In the theoretical reallocation components, this corresponds to assuming no change in the actual portfolio share, so that the reallocation is equal to minus the change in the passive portfolio share. If for example equity prices rise relative to bond prices, so that the passive portfolio share in equity increases, there would be a reallocation from equity to bonds if there were portfolio rebalancing. We can then compare the actual portfolio reallocation to what it would have been under perfect portfolio rebalancing.

Portfolio flows at all levels of aggregation can be quite volatile at the quarterly frequency, which makes for ugly graphs. For the first three decompositions we therefore only show graphs of cumulative flows and two-year moving averages. Let y_t be the quarterly portfolio flow for a particular decomposition (e.g. equity outflows in the third decomposition) and x_{nt} a particular component of the decomposition. Then $y_t = \sum_{n=1}^{N} x_{nt}$. If the time interval is $[1, T]$, the graphs report the cumulative flows $\sum_{s=1}^{t} y_s$ and cumulative components $\sum_{s=1}^{t} x_{ns}$, for $t = 1$ to $t = T$, as well as two-year moving averages $\sum_{s=t-7}^{t} y_s/8$ and $\sum_{s=t-7}^{t} x_{ns}/8$ for $t = 8$ to $t = T$.

Starting with Table 3, the tables report various moments associated with portfolio purchases and its components at the quarterly and annual frequencies. They also report variance decompositions, which attribute a fraction of the variance of y_t to component n equal to

$$\frac{cov(x_{nt}, y_t)}{var(y_t)} \tag{1.28}$$

These fractions add to 1. In these tables, in contrast to the figures, we scale y_t and x_{nt} by the corresponding stock of assets at the end of the quarter prior to the period over which the flows are measured to assure stationarity (e.g. the US equity portfolio when decomposing equity purchases in the second decomposition).

Tables 1 and 2 provide different information. Table 1 reports the fraction of the (unscaled) cumulative portfolio flow over the entire sample that can be attributed to component n. This is equal to $\sum_{s=1}^{T} x_{ns} / \sum_{s=1}^{T} y_s$. It provides insight into the role of various components over a longer period of time. Table 2 reports the correlation at the quarterly and annual frequencies between various portfolio reallocation components and what they would have been under perfect rebalancing. We will return to Tables 1 and 2 throughout the analysis of the first three decompositions.

Table 1.1: Cumulative Components Entire Sample as Share of Cumulative Flows

	Decomposition 1	**Decomposition 2**		**Decomposition 3**	
Variable		Equity	Bond	Equity	Bond
Portfolio growth	1.23	2.71	0.84	0.52	0.45
Portfolio - non-portfolio reallocation	-0.23	0.12	-0.31	0.01	-0.18
Equity - bond reallocation		-1.83	0.47	-0.32	0.24
Home - Foreign reallocation				0.79	0.49

Notes: All components and flows are cumulative over the entire sample, 1994Q3 to 2014Q4. Cumulative flows in the first decomposition through the third decomposition are cumulative portfolio flows, cumulative equity and bond purchases, and cumulative equity and bond outflows, respectively.

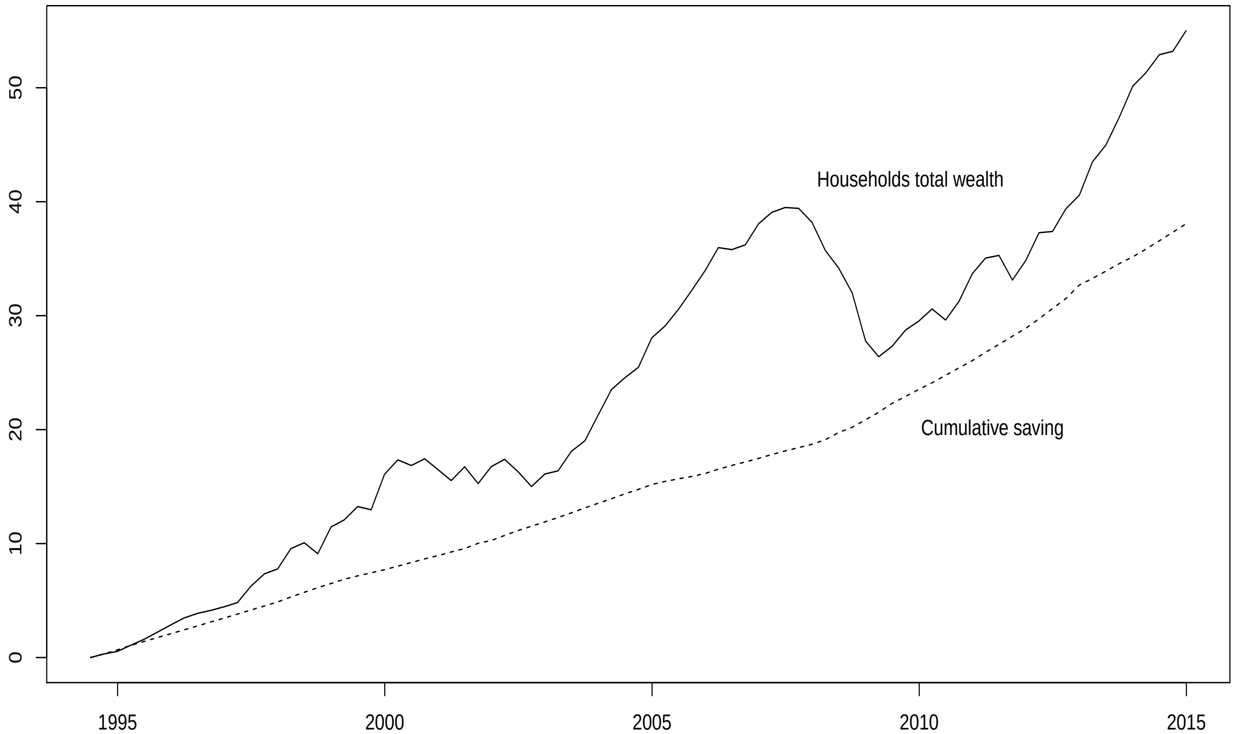
Table 1.2: Correlation Between Various Reallocation Components and Perfect Rebalancing

	Decomposition 1	**Decomposition 2**		**Decomposition 3**	
Frequency	Portfolio - non-portfolio	Equity - bond	Bond - equity	H - F equity	H - F bond
Quarterly	0.550	-0.125	-0.076	0.222	0.030
Annual	0.778	0.053	0.154	0.428	-0.074
Bi-annual	0.777	0.242	0.217	0.521	-0.230

Notes: Perfect rebalancing refers to what reallocation would have been if agents keep their portfolio share constant. In the first decomposition, portfolio share refers to asset allocation between portfolio assets and non-portfolio assets; in the second decomposition, portfolio share refers to the allocation of portfolio assets to equity and bonds; in the third reallocation, portfolio share refers to the allocation of equity and bond portfolio between Home and Foreign equity and bonds. All reallocation and rebalancing components are scaled by asset holdings in the prior quarter.

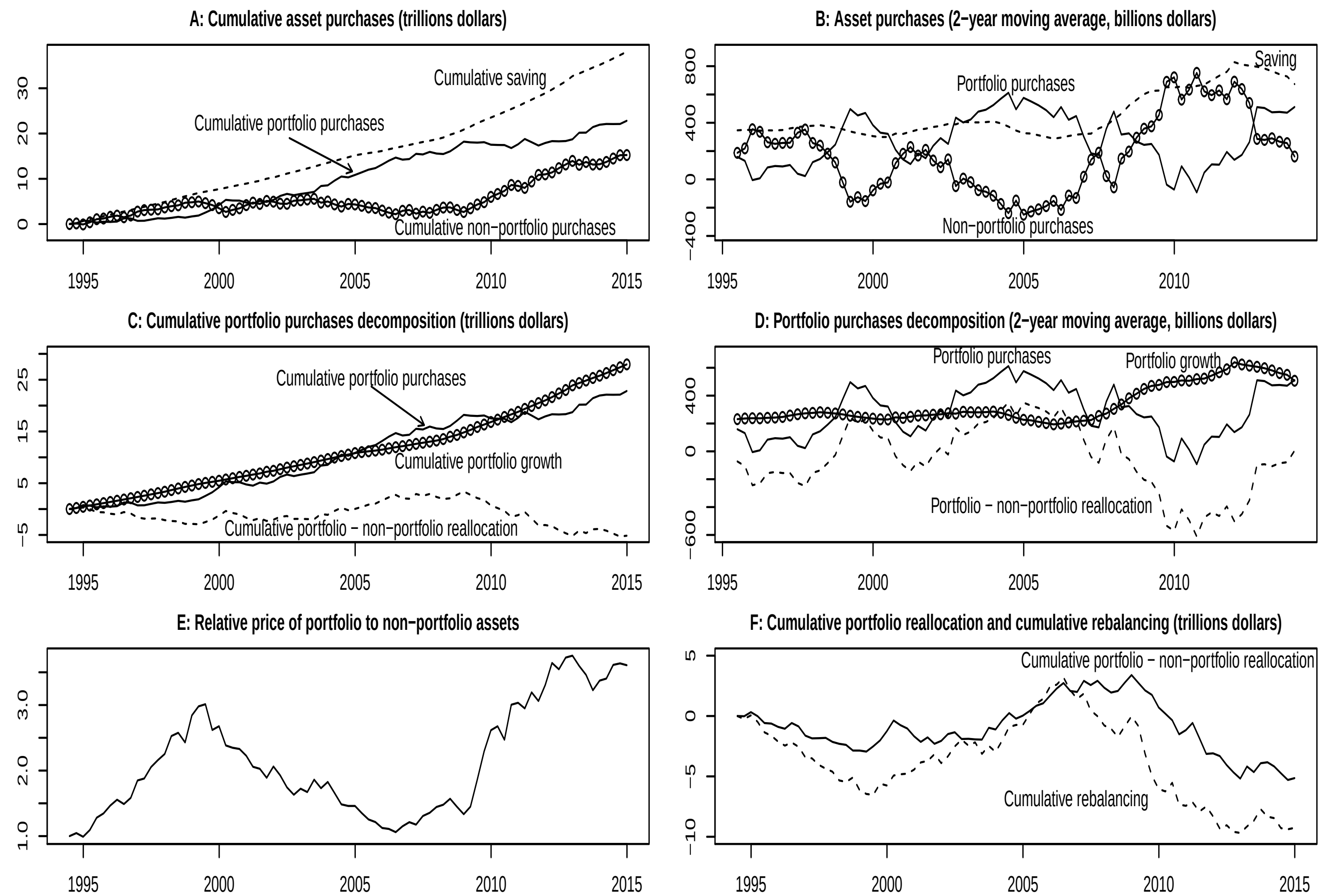
1.4.1 First Decomposition

Figure 1.2: Total Wealth and Cumulative Saving (trillions dollars)



In Figure 2 we start at the very top of the decision tree. It shows household wealth as well as cumulative net private saving. The difference is due to valuation effects. For asset purchases what matters is not changes in total household wealth, but saving. The sum of all asset purchases equals saving. Cumulative saving grows at a steady pace until the global financial crisis, after which it accelerates. The increase in saving since 2008 is related to a process of deleveraging as many households became overextended in mortgage debt after the drop in real estate values that started in the summer of 2006.

Figure 1.3: Portfolio Purchases Decomposition



Notes: Cumulative rebalancing in chart F refers to what cumulative portfolio - non-portfolio reallocation would have been under perfect rebalancing, where agents hold constant the share allocated to portfolio and non-portfolio assets.

Figure 3 relates to the first decomposition. Panel A shows cumulative portfolio and non-portfolio purchases, as well as their sum (cumulative saving). Panel B is the same, but based on two-year moving averages. Panels C and D show results for the first decomposition. Panel C shows cumulative flows, while panel D shows two-year moving averages.

Portfolio growth is by far the most important driver of portfolio purchases over the entire sample. Table 1 shows that it accounts for 123 percent of cumulative portfolio purchases during the entire sample. Panel C of Figure 3 shows that cumulative portfolio purchases closely track cumulative portfolio growth during most of the sample. Since the financial crisis cumulative portfolio purchases have grown less rapidly than cumulative non-portfolio purchases (Panel A), associated with a portfolio reallocation from portfolio to non-portfolio assets (panels C, D).

Table 1.3: First Decomposition Statistics

Variable	Mean	Std. Dev.	Std. Dev. (relative to portfolio purchases)	Auto-correlation	Correlation with portfolio purchases	Variance decomposition
Panel A. Quarterly data						
Portfolio purchases	0.008	0.015	1.00	0.125	1.000	1.000
Portfolio growth	0.010	0.003	0.20	0.818	-0.172	-0.036
Portfolio - non-portfolio reallocation	-0.002	0.016	1.07	0.200	0.981	1.036
Panel B. Annual data						
Portfolio purchases	0.035	0.033	1.00	-0.188	1.000	1.000
Portfolio growth	0.042	0.012	0.36	0.773	-0.237	-0.085
Portfolio - non-portfolio reallocation	-0.007	0.038	1.15	0.112	0.952	1.085

Notes: The sample period is from 1994Q3 to 2014Q4. All components above are normalized by U.S. portfolio holdings in the quarter prior to the measured flows. The variance decomposition shows the fraction of the variance of portfolio purchases accounted for by each component.

Table 3 reports on the higher frequency aspects of the data. It leaves a very different impression than panel C of Figure 3. While over the entire sample cumulative portfolio purchases are mostly driven by cumulative portfolio growth, at the quarterly and annual frequencies considered in Table 3 there is a somewhat negative correlation between the portfolio growth component and portfolio purchases. At both the quarterly and annual frequency virtually all of the variance of portfolio purchases can be attributed to the reallocation between portfolio and non-portfolio assets. Table 3 also shows that portfolio growth has a high autocorrelation, while the reallocation component has very little persistence.

Portfolio reallocation appears closely related to portfolio rebalancing. Table 2 shows a significant correlation between portfolio/non-portfolio reallocation and what it would have been under perfect rebalancing. At the annual frequency the correlation is 0.78. It is slightly lower at the quarterly frequency. Panel F of Figure 3 provides a longer term view, reporting cumulative portfolio reallocation and what it would have been under rebalancing. Panel E shows the relative price of portfolio to non-portfolio assets, which rose sharply as a result of the financial crisis. There was a sharp drop in real estate values (a non-portfolio asset) and a strong stock market recovery after the crisis. Such an increase in the relative price of portfolio assets implies a reallocation towards non-portfolio assets under rebalancing. Panel F shows that cumulative portfolio reallocation follows a similar pattern as it would under portfolio rebalancing, although somewhat smoother.

We can summarize these findings as follows.

Empirical Finding 1 *The following results apply to the first decomposition:*

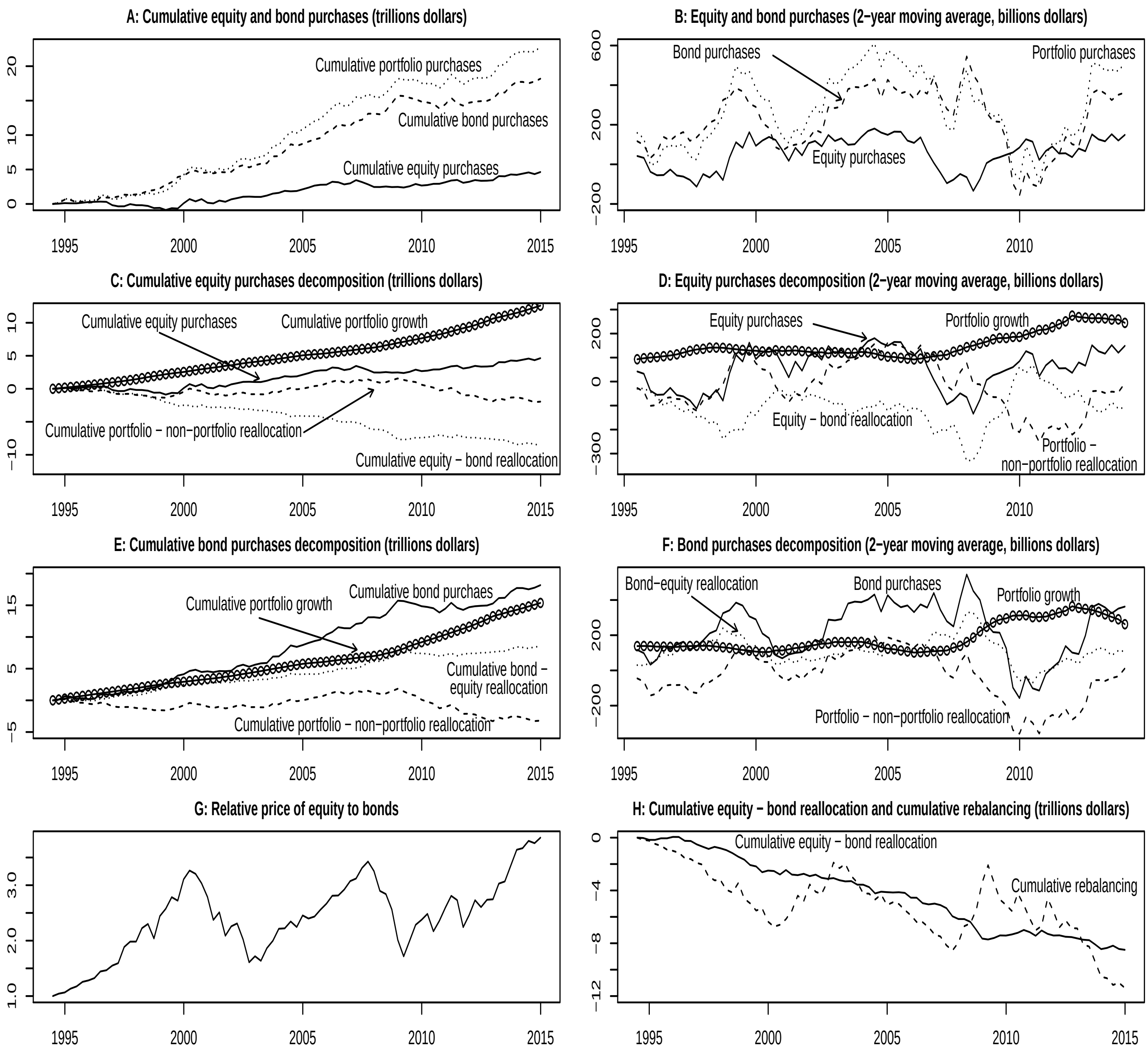
- *Cumulative portfolio purchases over the two decade sample are almost entirely driven by portfolio growth.*
- *At the quarterly and annual frequencies reallocation between portfolio and non-portfolio assets is the main driver of portfolio purchases.*
- *Portfolio growth is highly persistent, while the reallocation component shows little persistence.*
- *The reallocation is highly correlated with what it would have been under perfect rebalancing.*

1.4.2 Second Decomposition

We next consider the breakdown of portfolio purchases into equity and bond purchases. Figure 4 reports results related to the second decomposition. Panel A shows cumulative equity and bond purchases and their sum (portfolio purchases). Panel B shows corresponding two-year moving averages. Panels C and D show the second decomposition for equity purchases (cumulative and two-year moving average), while panels E and F show the same results for bond purchases. The last two panels relate to the role of portfolio rebalancing.

Panels A and B show that the bulk of portfolio purchases are bond purchases. Over the entire sample panels C and E show that the portfolio growth component is by far the biggest driver. This can also be seen in Table 1. The ratio of the cumulative portfolio growth component to cumulative equity purchases over the entire sample is 2.7, while for bonds it is 0.8. Table 1 shows that the next largest driver over the entire sample is the reallocation from equity to bonds. It reduces cumulative equity purchases over the sample by 68% relative to that based on portfolio growth alone.

Figure 1.4: Equity and Bond Purchases Decomposition



Notes: Cumulative rebalancing in chart H refers to what cumulative equity - bond reallocation would have been under perfect rebalancing, where agents hold constant the share of portfolio assets allocated to equity and bonds.

At a higher frequency again a different picture emerges. While Table 1 and panels C and E of Figure 4 show that the reallocation between portfolio and non-portfolio assets is not a key driver of cumulative equity and bond purchases over the entire sample, Tables 4 and 5 show that it is the main driver at the quarterly and annual frequencies. It accounts for between 60 and 70 percent of the variance of equity and bond purchases at the quarterly and annual frequencies, while portfolio growth accounts for a small negative fraction. Tables 4 and 5 also show that the reallocation components have little persistence, while the portfolio growth component has significant persistence.

Table 1.4: Second Decomposition Statistics (Equity)

Variable	Mean	Std. Dev.	Std. Dev. (relative to equity purchases)	Auto-correlation	Correlation with equity purchases	Variance decomposition
Panel A. Quarterly data						
Equity purchases	0.003	0.016	1.00	0.051	1.000	1.000
Portfolio growth	0.010	0.003	0.19	0.818	-0.080	-0.016
Portfolio - non-portfolio reallocation	-0.002	0.016	1.00	0.200	0.611	0.604
Equity - bond reallocation	-0.007	0.013	0.81	0.048	0.475	0.387
Panel B. Annual data						
Equity purchases	0.016	0.034	1.00	-0.041	1.000	1.000
Portfolio growth	0.042	0.012	0.35	0.754	-0.047	-0.019
Portfolio - non-portfolio reallocation	-0.007	0.038	1.12	0.111	0.568	0.683
Equity - bond reallocation	-0.027	0.029	0.85	-0.097	0.400	0.358

Notes: The sample period is from 1994Q3 to 2014Q4. All components above are normalized by U.S. equity holdings in the quarter prior to the measured flows. The variance decomposition shows the fraction of the variance of equity purchases accounted for by each component.

Table 1.5: Second Decomposition Statistics (Bonds)

Variable	Mean	Std. Dev.	Std. Dev. (relative to bond purchases)	Auto-correlation	Correlation with bond purchases	Variance decomposition
Panel A. Quarterly data						
Bond purchases	0.013	0.021	1.00	0.091	1.000	1.000
Portfolio growth	0.010	0.003	0.14	0.818	-0.178	-0.026
Portfolio - non-portfolio reallocation	-0.002	0.016	0.76	0.200	0.840	0.616
Bond - equity reallocation	0.006	0.012	0.57	-0.013	0.735	0.398
Panel B. Annual data						
Bond purchases	0.053	0.048	1.00	-0.157	1.000	1.000
Portfolio growth	0.042	0.012	0.25	0.719	-0.235	-0.056
Portfolio - non-portfolio reallocation	-0.007	0.038	0.79	0.113	0.849	0.650
Bond - equity reallocation	0.025	0.026	0.54	-0.002	0.775	0.416

Notes: The sample period is from 1994Q3 to 2014Q4. All components above are normalized by U.S. bond holdings in the quarter prior to the measured flows. The variance decomposition shows the fraction of the variance of bond purchases accounted for by each component.

Table 2 indicates that the reallocation between equity and bonds is not much correlated with what it would be under perfect rebalancing. While there appears little relation between the two at the quarterly and annual frequencies, panel H of Figure 4 shows that over the entire sample cumulative reallocation closely tracks what it would be as a result of rebalancing. Actual reallocation between equity and bonds is essentially a "smoothed" version of what it would be under perfect rebalancing. Panel G shows that the relative price of equity to bonds more than triples during the sample. This implies significant rebalancing if agents wish to keep the portfolio share in equity and bonds unchanged. It is noteworthy that both the cumulative reallocation between portfolio and non-portfolio assets and between equity and bonds broadly track what they would be under perfect portfolio rebalancing.

We can summarize these findings as follows.

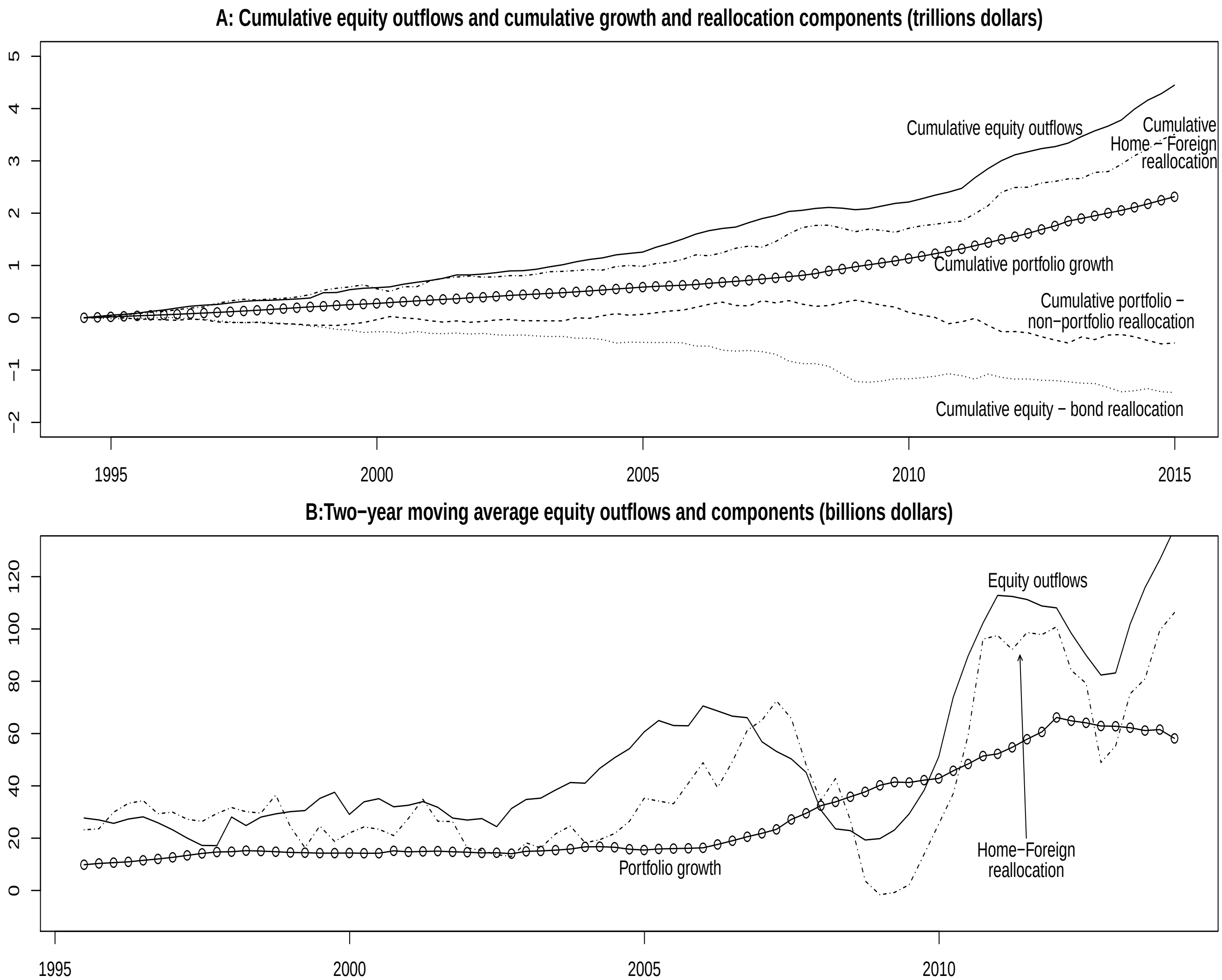
Empirical Finding 2 *The following results apply to the second decomposition:*

- *Over the entire sample equity and bond purchases are mostly driven by portfolio growth and a significant reallocation from equity to bonds.*
- *At the quarterly and annual frequencies, portfolio- non-portfolio reallocation accounts for most of the variance of equity and bond purchases.*
- *Portfolio growth is highly persistent, while the two reallocation components show little persistence.*
- *Both types of reallocation, when cumulated over time, are a "smoothed" version of what they would be under perfect rebalancing.*

1.4.3 Third Decomposition

We are now in a position to consider the decomposition of capital flows. Figure 5 reports results related to the third decomposition for equity outflows. Panel A shows cumulative equity outflows and its four components, while panel B shows two-year moving averages. In order to avoid an excessive number of lines, the latter only shows equity outflows, the portfolio growth component and the reallocation between Home (U.S.) and Foreign equity.

Figure 1.5: Equity Outflows Decomposition



Panel A of Figure 5 shows that portfolio growth and reallocation between Home and Foreign equity are the key drivers of equity outflows over the entire sample. Table 1 shows that cumulative portfolio growth accounts for about half of the cumulative equity outflows during the sample, while cumulative reallocation from Home to Foreign equity accounts for 79 percent. The reallocation from equity to bonds plays an

Table 1.6: Third Decomposition Statistics (Equity)

Variable	Mean	Std. Dev.	Std. Dev. (relative to equity outflows)	Auto-correlation	Correlation with equity outflows	Variance decomposition
Panel A. Quarterly data						
Equity outflows	0.021	0.014	1.00	0.256	1.000	1.000
Portfolio growth	0.010	0.003	0.21	0.818	0.116	0.026
Portfolio - non-portfolio reallocation	-0.002	0.016	1.14	0.200	0.115	0.130
Equity - bond reallocation	-0.007	0.013	0.93	0.048	0.068	0.064
Home - Foreign reallocation	0.016	0.019	1.36	0.275	0.548	0.761
Panel B. Annual data						
Equity outflows	0.088	0.044	1.00	0.270	1.000	1.000
Portfolio growth	0.042	0.013	0.30	0.726	0.457	0.133
Portfolio - non-portfolio reallocation	-0.006	0.041	0.93	0.115	0.021	0.020
Equity - bond reallocation	-0.028	0.030	0.68	-0.127	0.034	0.024
Home - Foreign reallocation	0.070	0.051	1.16	0.079	0.746	0.867

Notes: The sample period is from 1994Q3 to 2014Q4. All components above are normalized by U.S. external equity holdings in the quarter prior to the measured flows. The variance decomposition shows the fraction of the variance of equity outflows accounted for by each component.

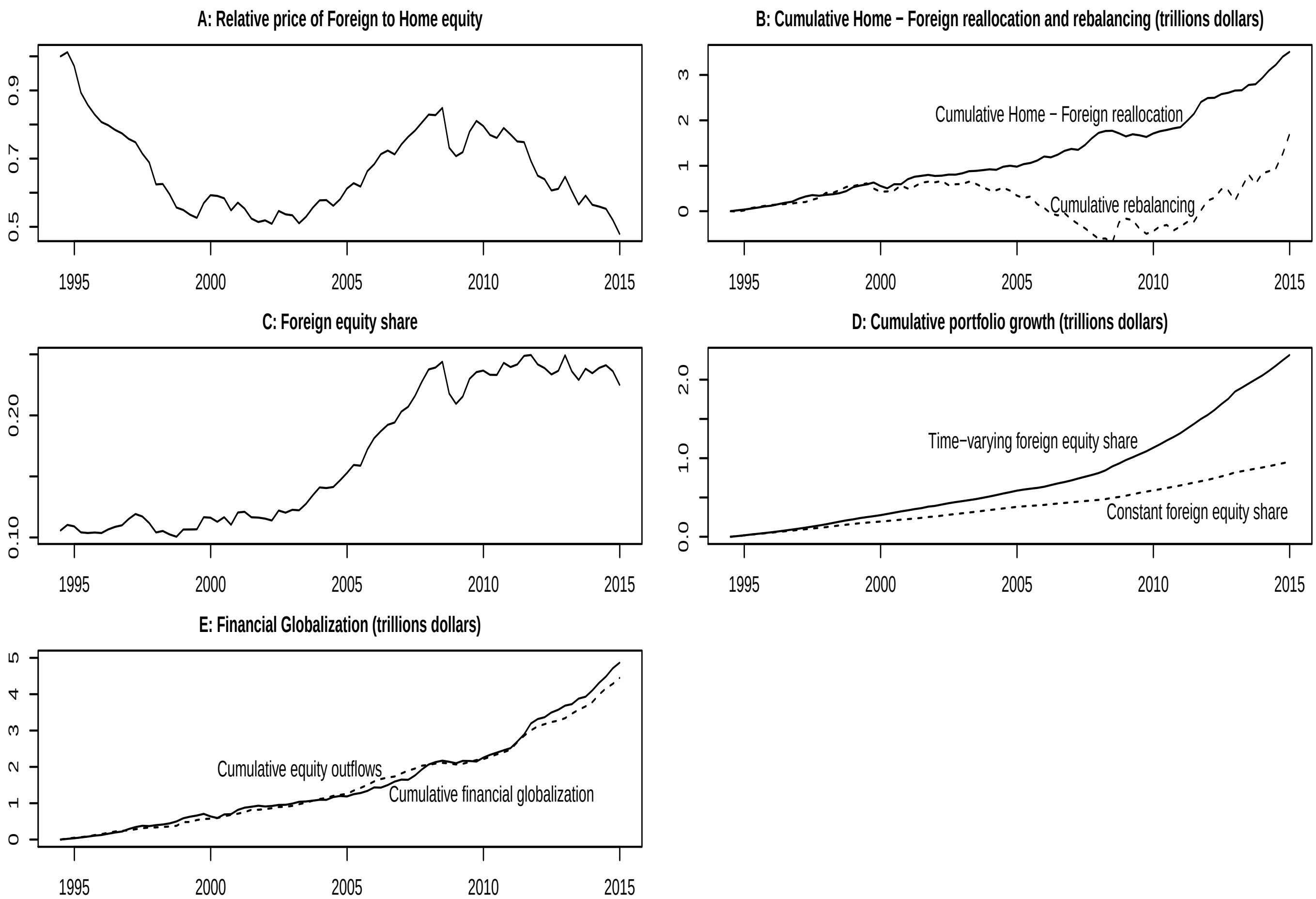
important role as well, reducing cumulative equity outflows by 32 percent.

As we found for the other decompositions, portfolio growth plays much less of a role at higher frequencies, as shown in Table 6. At the quarterly and annual frequencies, reallocation between Home and Foreign equity accounts for about 80 percent of the variance of equity outflows. Portfolio growth accounts for only 3 percent of the variance of equity outflows at the quarterly frequency and 13 percent at the annual frequency. This can also be seen graphically in panel B of Figure 5. Although they use a somewhat different approach, Guo and Jin (2009) also find that the “composition” effect (related to various types of reallocation) is a much more important driver of capital flows than the “growth effect” at high frequencies. They do not consider the role of portfolio growth in the long run.

The other two reallocation components, between equity and bonds and between portfolio and non-portfolio assets, have a volatility comparable to that of equity outflows itself at quarterly and annual frequencies. But they are not very correlated with equity outflows and therefore account for very little of the variance of equity outflows at these frequencies. We also find that portfolio growth has much more persistence than all of the reallocation components, contributing to its importance in the long run.

Figure 6 provides further insight into portfolio reallocation from Home to Foreign equity. Panel A shows the relative price of Foreign to Home equity. While this has fluctuated over the sample, overall the relative price of US equity has about doubled during the sample. Under rebalancing, this would lead to purchases of Foreign equity. But Panel B shows that the actual cumulative reallocation from Home to Foreign equity is much larger than it would be based on rebalancing. This contrasts to the earlier results, where we found that cumulative reallocation (between portfolio and non-portfolio assets and between equity and bonds) broadly tracks that based on portfolio rebalancing.

Figure 1.6: Equity Globalization and Rebalancing



Notes: Cumulative rebalancing in chart B refers to what cumulative Home - Foreign equity reallocation would have been under perfect rebalancing, where agents hold constant the share of the equity portfolio allocated to Home and Foreign equity. Cumulative financial globalization in chart E equals cumulative Home - Foreign equity reallocation (chart B) plus the part of portfolio growth that is due to the increase in the portfolio share (difference between the two lines in chart D).

The finding that cumulative reallocation between Home and Foreign equity appears to have little relation with what it would be based on rebalancing does not necessarily imply that rebalancing is not important. Table 2 shows that the Home-Foreign equity reallocation component has a correlation with its perfect rebalancing counterpart of 0.43 at the annual frequency. Rebalancing clearly does play a role. But panel B of Figure 6 shows that over the entire two decade sample other factors are more dominant. Lane and Milesi-Ferretti (2008) attribute the increase in cross-border positions to factors such as capital account liberalization, financial deregulation, falling communication costs as well as financial innovation (e.g. securitization).

Defining financial globalization as the process of reallocation from Home to Foreign assets, panels C, D and E of Figure 6 shed further light on the effect that it has on capital flows. If for whatever reason there is a portfolio reallocation from Home to Foreign equity, it raises capital outflows. This effect on capital outflows is temporary in the sense that it ends once the reallocation is completed. A lower cost of investing abroad, even if it is permanent, temporarily raises capital outflows during the process of reallocation. This reallocation goes back to zero once portfolios have settled at their new level. However, to the extent that changes in portfolio shares are persistent, the reallocation has a persistent effect on portfolio growth.

This persistent effect of portfolio reallocation is illustrated in panel D of Figure 6. Panel C shows that the share of the equity portfolio allocated to Foreign equity increased from about 10 percent at the start of the sample to 25 percent by the end of the sample. Panel D compares cumulative portfolio growth to what it would have been if the portfolio share in Foreign equity had remained constant at its level during the start of the sample. The difference between these two lines captures the persistent effect of financial globalization. Define equity outflows associated with cumulative financial globalization as the sum of cumulative reallocation from Home to Foreign equity and the part of cumulative portfolio growth associated with financial globalization (difference between the two lines in panel D). Panel E shows that total cumulative equity outflows are about equal to that based on cumulative financial globalization.

Analogous results for bond outflows are reported in Figures 7 and 8 and Tables 1 and 7. Table 1 shows that over the entire sample portfolio growth and reallocation from Home to Foreign bonds both account for about half of bond outflows. The other two reallocation components, from equity to bonds and portfolio to non-portfolio assets, are not insignificant, but go in opposing directions. At quarterly and annual frequencies, Table 7 shows that reallocation between Home and Foreign bonds accounts for virtually all of the variance of bond outflows.

Figure 1.7: Bond Outflows Decomposition

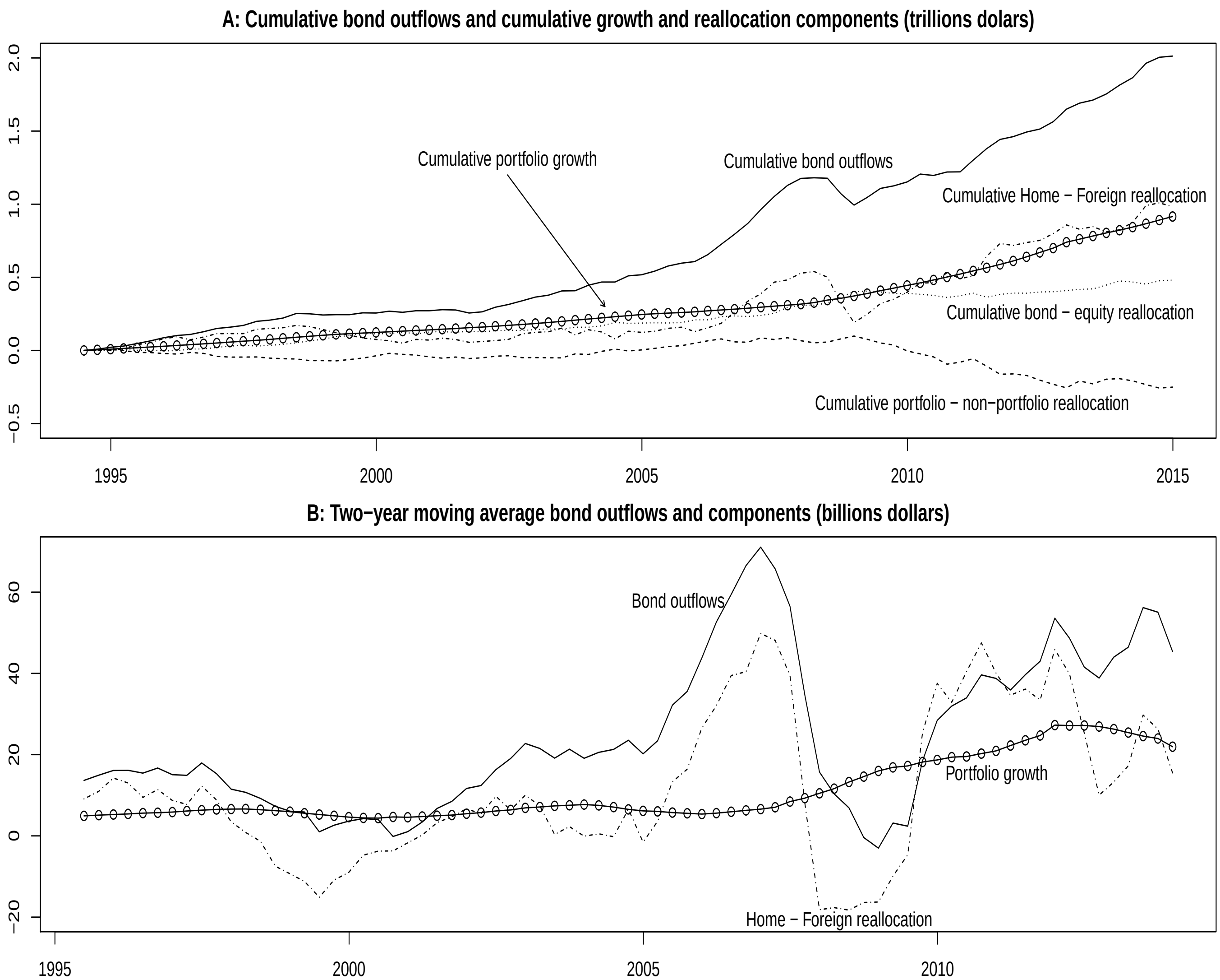
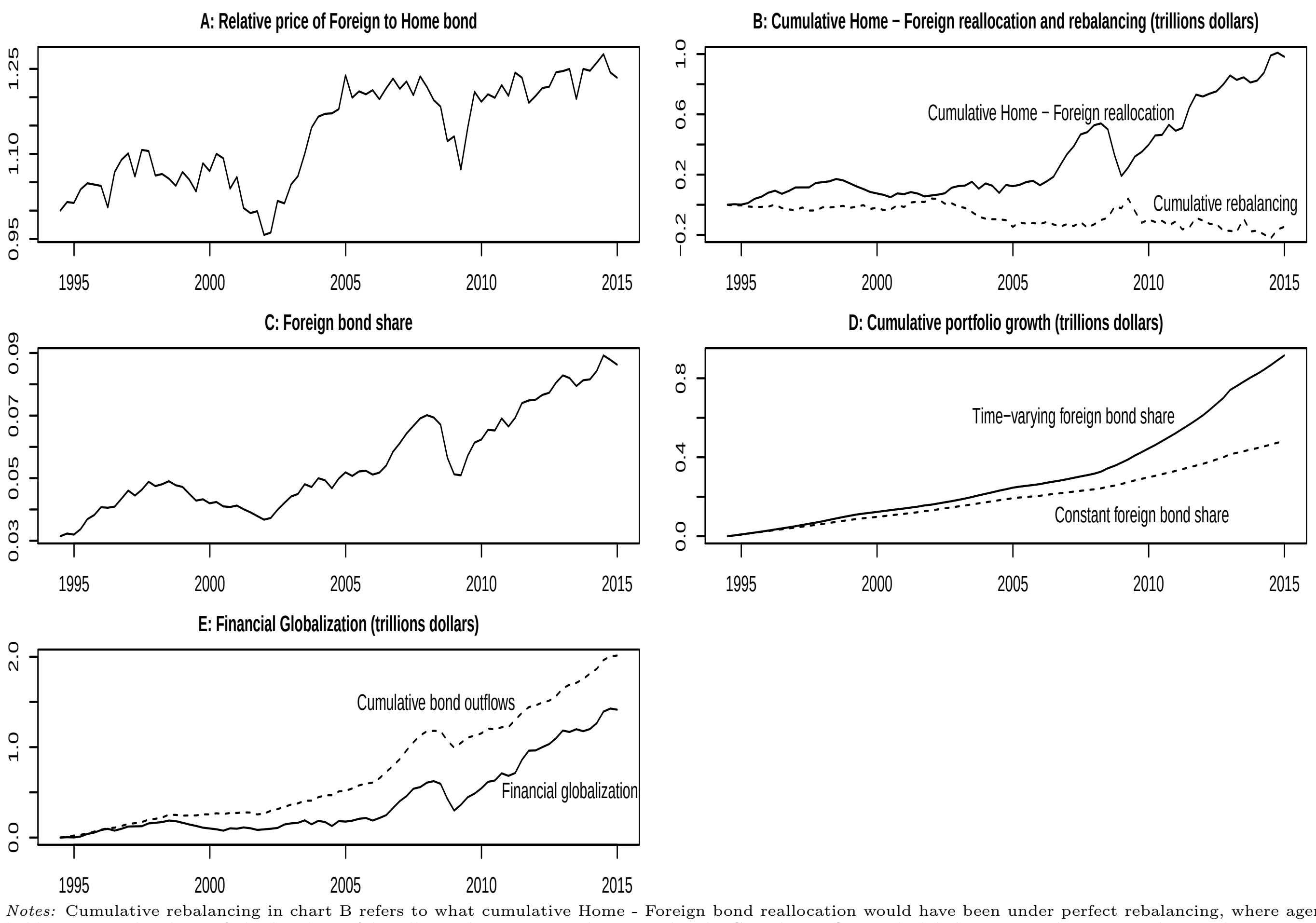


Figure 8 sheds further insight into the reallocation from Home to Foreign bonds. Since the relative price of Foreign bonds to Home bonds has not changed a lot (panel A), reallocation under portfolio rebalancing is not very large (panel B). As is the case for equity, the large cumulative portfolio reallocation from Home to Foreign bonds is therefore driven by factors other than rebalancing, such as reduced barriers to foreign bond investment. In contrast to equity, for bonds rebalancing does not play much of a role at higher frequencies either (Table 2).

Figure 1.8: Bond Globalization and Rebalancing



Notes: Cumulative rebalancing in chart B refers to what cumulative Home - Foreign bond reallocation would have been under perfect rebalancing, where agents hold constant the share of the bond portfolio allocated to Home and Foreign bond. Cumulative financial globalization in chart E equals cumulative Home - Foreign bond reallocation (chart B) plus the part of portfolio growth that is due to the increase in the portfolio share (difference between the two lines in chart D).

The increase in the share of the bond portfolio allocated to Foreign bonds during the sample (panel C) implies that again a large part of the cumulative portfolio growth component of bond outflows can be attributed to financial globalization (difference between the lines in panel D). Panel E shows that cumulative bond outflows is related to a large extent, though not entirely, to cumulative financial globalization as defined above.

Table 1.7: Third Decomposition Statistics (Bonds)

Variable	**Mean**	**Std. Dev.**	**Std. Dev. (relative to bond outflows)**	**Auto-correlation**	**Correlation with bond outflows**	**Variance decomposition**
Panel A. Quarterly data						
Bond outflows	0.023	0.025	1.00	0.444	1.000	1.000
Portfolio growth	0.010	0.003	0.12	0.818	-0.015	-0.002
Portfolio - non-portfolio reallocation	-0.002	0.016	0.64	0.200	-0.158	-0.098
Bond - equity reallocation	0.006	0.012	0.48	-0.013	-0.286	-0.131
Home - Foreign reallocation	0.011	0.036	1.44	0.268	0.819	1.170
Panel B. Annual data						
Bond outflows	0.100	0.074	1.00	0.279	1.000	1.000
Portfolio growth	0.042	0.012	0.16	0.792	-0.024	-0.004
Portfolio - non-portfolio reallocation	-0.007	0.038	0.51	0.115	-0.104	-0.054
Bond - equity reallocation	0.025	0.026	0.35	0.025	-0.276	-0.097
Home - Foreign reallocation	0.047	0.093	1.26	-0.031	0.860	1.087

Notes: The sample period is from 1994Q3 to 2014Q4. All components above are normalized by U.S. external bond holdings in the quarter prior to the measured flows. The variance decomposition shows the fraction of the variance of bond outflows accounted for by each component.

We can summarize these findings as follows.

Empirical Finding 3 *The following results apply to the third decomposition:*

- *Over the entire sample, equity and bond outflows are mostly driven by portfolio growth and reallocation between Home and Foreign equity/bonds.*
- *At quarterly and annual frequencies, portfolio reallocation between Home and Foreign equity/bonds accounts for virtually all of capital outflow volatility.*
- *Reallocation between Home and Foreign equity/bonds are largely driven by factors other than rebalancing.*

- *Portfolio growth is significantly more persistent than all reallocation components.*
- *A lasting impact of portfolio reallocation to Foreign equity/bonds is a significantly larger portfolio growth component.*

1.4.4 Fourth Decomposition

In the fourth decomposition the new component is the reallocation between foreign countries. At the quarterly and annual frequencies the evidence clearly indicates that this is the dominant driver of US capital outflows to individual foreign countries. Figures 9 and 10 show quarterly equity and bond outflows to 12 individual foreign countries (solid line) as well as the part associated with reallocation between that country and other foreign countries (broken line). In contrast to previous graphs, these are actual quarterly flows, not cumulated flows. There is clearly a very close connection between the two.

This is confirmed in Tables 8 and 9, which show the variance decomposition for equity and bonds and related moments. The moments reported in Tables 8 and 9 are computed for each foreign country and then averaged across all foreign countries. Virtually all of the variance of quarterly and annual capital flows to individual countries is explained by the reallocation among foreign countries. This is the case for both equity (Table 8) and bonds (Table 9). This reallocation component is far more volatile than the other components and has an average correlation with equity flows and bond flows to individual countries of about 0.9.

A different picture emerges when we look at the cross-sectional aspect of the data, which captures more long term drivers of capital flows to individual countries. In Table 10 we report the cross-sectional variance decomposition of cumulative capital flows over the entire sample to individual countries. For both equity and bonds the main drivers of capital flows to individual foreign countries in the long run are portfolio growth and the reallocation between Home and Foreign countries. The other reallocation components, including reallocation between foreign countries, play a role as well, but are smaller.

One can also ask to what extent the reallocation between foreign countries is associated with portfolio rebalancing. We compute the correlation between foreign country reallocation and what it would have been based on perfect rebalancing. The average of this correlation across all countries is -0.07 for equity and 0.02 for bonds for quarterly data. This implies that at least at the high frequency there is virtually no rebalancing.

Figure 1.9: Equity Outflows to Individual Foreign Countries and Foreign Country Reallocation (Quarterly, millions of dollars)

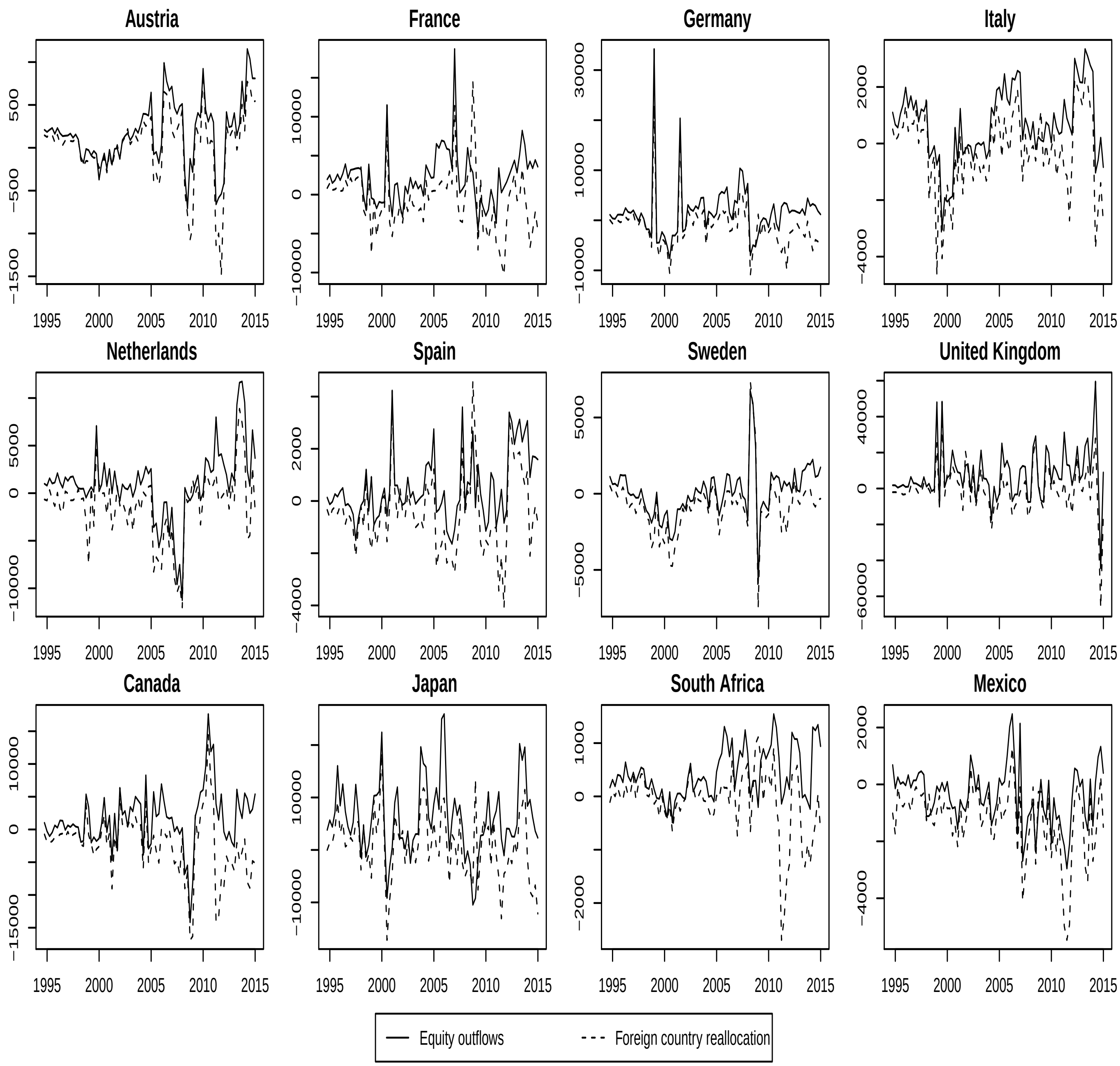


Figure 1.10: Bond Outflows to Individual Foreign Countries and Foreign Country Reallocation (Quarterly, millions of dollars)

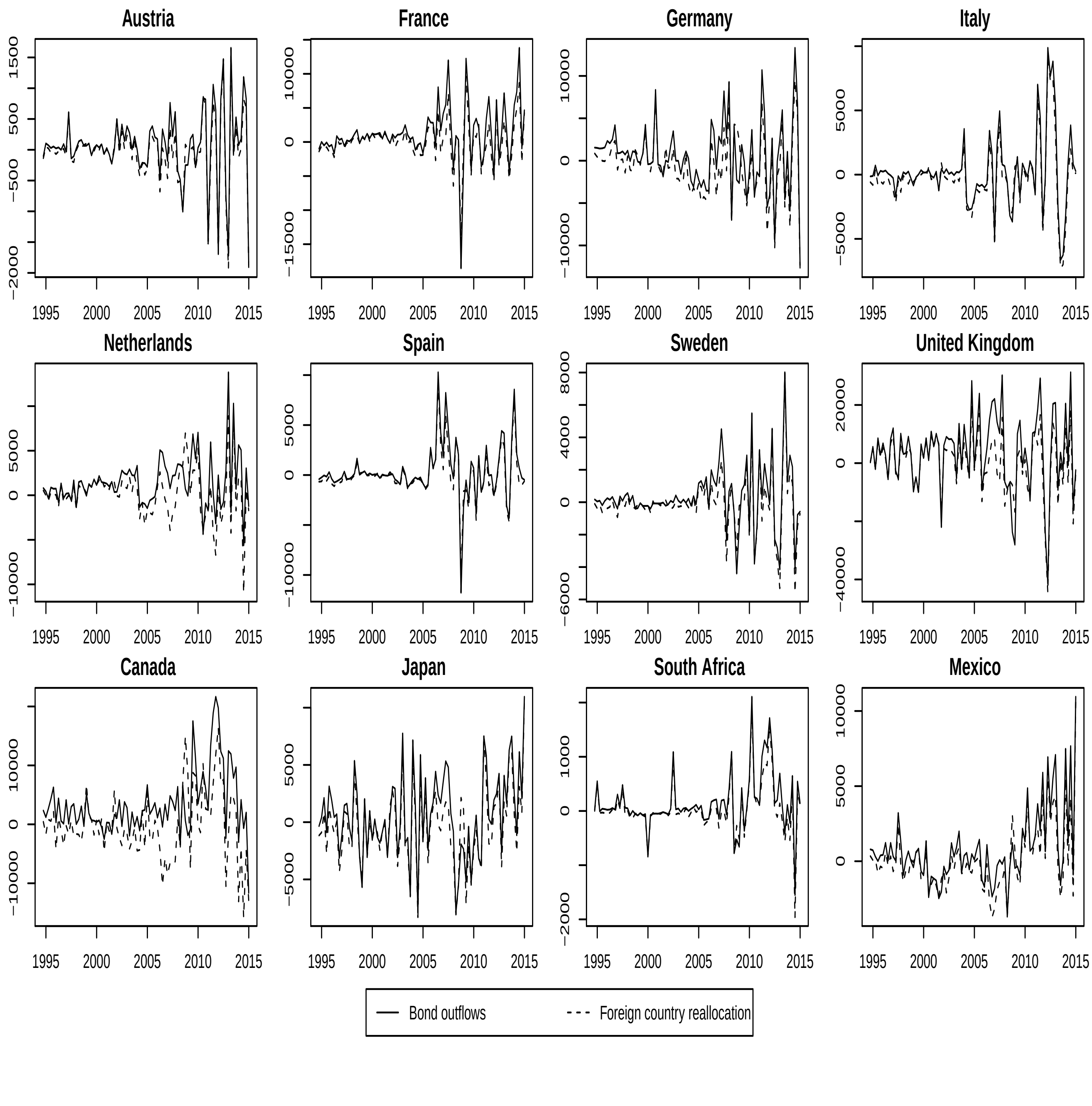


Table 1.8: Fourth Decomposition Statistics (Equity)

Variable	**Mean**	**Std. Dev.**	**Std. Dev. (relative to equity outflows)**	**Auto-correlation**	**Correlation with equity outflows**	**Variance decomposition**
Panel A. Quarterly data						
Equity outflows	0.060	0.294	1.00	0.392	1.000	1.000
Portfolio growth	0.010	0.003	0.01	0.818	0.143	0.011
Portfolio - non-portfolio reallocation	-0.002	0.016	0.05	0.200	-0.002	0.001
Equity - bond reallocation	-0.007	0.013	0.04	0.048	0.026	0.007
Home - Foreign reallocation	0.016	0.019	0.06	0.275	0.133	0.069
Foreign country reallocation	0.036	0.284	0.97	0.314	0.895	0.878
Panel B. Annual data						
Equity outflows	0.189	0.411	1.00	0.359	1.000	1.000
Portfolio growth	0.044	0.016	0.04	0.567	0.412	0.036
Portfolio - non-portfolio reallocation	-0.006	0.045	0.11	0.129	-0.103	-0.015
Equity - bond reallocation	-0.029	0.033	0.08	-0.120	-0.034	-0.011
Home - Foreign reallocation	0.074	0.056	0.14	0.110	0.429	0.149
Foreign country reallocation	0.087	0.380	0.93	0.296	0.898	0.797

Notes: The sample period is from 1994Q3 to 2014Q4. All values above are averages across countries. All components above are normalized by equity holdings in individual foreign countries in the quarter prior to the measured flows. The variance decomposition shows the average fraction of the variance of equity outflows to individual foreign countries accounted for by each component.

Table 1.9: Fourth Decomposition Statistics (Bonds)

Variable	**Mean**	**Std. Dev.**	**Std. Dev. (relative to bond outflows)**	**Auto-correlation**	**Correlation with bond outflows**	**Variance decomposition**
Panel A. Quarterly data						
Bond outflows	0.026	0.099	1.00	0.105	1.000	1.000
Portfolio growth	0.010	0.003	0.03	0.818	0.049	0.005
Portfolio - non-portfolio reallocation	-0.002	0.016	0.16	0.200	-0.049	-0.017
Bond - equity reallocation	0.006	0.012	0.12	-0.013	-0.075	-0.016
Home - Foreign reallocation	0.011	0.036	0.36	0.268	0.247	0.134
Foreign country reallocation	0.002	0.093	0.94	0.094	0.911	0.863
Panel B. Annual data						
Bond outflows	0.108	0.235	1.00	0.185	1.000	1.000
Portfolio growth	0.042	0.014	0.06	0.772	0.116	0.013
Portfolio - non-portfolio reallocation	-0.008	0.038	0.16	0.129	-0.152	-0.041
Bond - equity reallocation	0.025	0.026	0.11	0.023	-0.205	-0.033
Home - Foreign reallocation	0.045	0.088	0.37	-0.042	0.333	0.176
Foreign country reallocation	0.010	0.220	0.94	0.214	0.900	0.853

Notes: The sample period is from 1994Q3 to 2014Q4. All values above are averages across countries. All components above are normalized by bond holdings in individual foreign countries in the quarter prior to the measured flows. The variance decomposition shows the average fraction of the variance of bond outflows to individual foreign countries accounted for by each component.

Table 1.10: Cross Sectional Variance Decomposition

Component	**Equity outflows**	**Bond outflows**
Portfolio growth	0.330	0.385
Portfolio - non-portfolio reallocation	-0.102	-0.135
Equity - bond reallocation	-0.197	0.194
Home - Foreign reallocation	0.453	0.447
Foreign country reallocation	0.188	0.122

Notes: The sample period is from 1994Q3 to 2014Q4. All outflows and components are cumulated over the entire sample, and are scaled by asset holdings at the beginning of the sample. The reported numbers measure the contribution of each component to the cross-sectional variance of cumulative equity and bond outflows.

Figure 11 sheds light on the long run relationship between rebalancing and reallocation between foreign countries. It reports on the horizontal axis the cumulative reallocation between a country and other foreign countries over the entire sample. On the vertical axis it shows what that reallocation would have been under perfect rebalancing.[16] There does not appear to be much of a relationship. This suggests that at both low and high frequencies the reallocation between foreign countries is mostly driven by factors unrelated to rebalancing.

We can summarize these findings as follows.

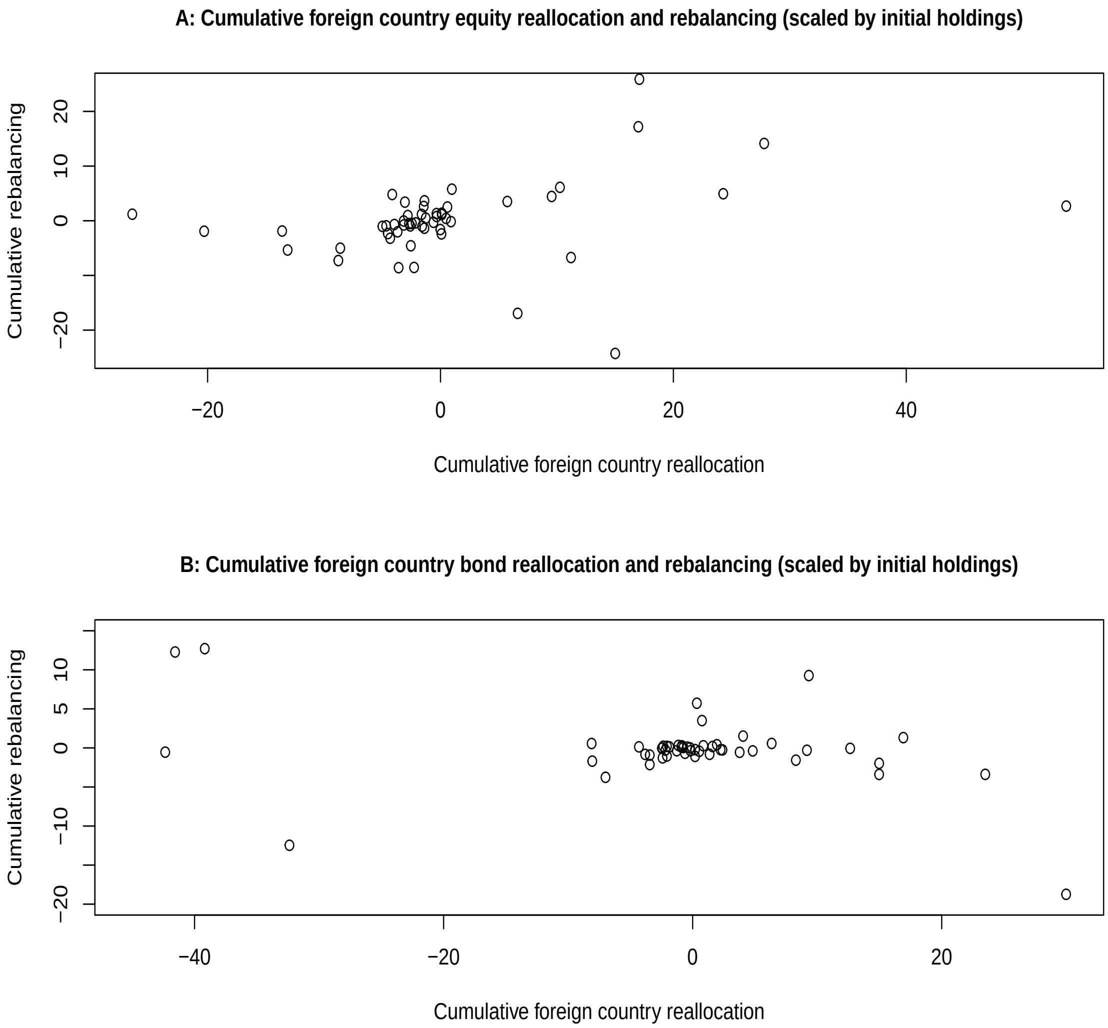
Empirical Finding 4 *The following results apply to the fourth decomposition:*

- *At the quarterly/annual frequency, reallocation between foreign countries accounts for virtually all of the variance of capital flows to individual countries.*
- *In the long run, portfolio growth and Home-Foreign reallocation (aggregate of foreign countries) account for most of capital flows to individual countries.*
- *Portfolio growth is much more persistent than all reallocation components.*

[16] We have removed one extreme outlier for equity and 4 outliers for bonds. For equity the outlier is Russia. For bonds the outliers are Serbia and Montenegro, Poland, Panama and Ghana.

- *Reallocation between foreign countries is mostly driven by factors unrelated to portfolio rebalancing.*

Figure 1.11: Cumulative Foreign Country Reallocation and Rebalancing



Notes: Each dot represents one foreign country. The top chart shows the cumulative foreign country equity reallocation over the entire sample and what it would have been under perfect rebalancing, where agents hold constant the share of the Foreign equity portfolio allocated to individual foreign countries. The bottom chart shows the cumulative foreign country bond reallocation over the entire sample and what it would have been under perfect rebalancing, where agents hold constant the share of the Foreign bond portfolio allocated to individual foreign countries. All reallocation and rebalancing components are normalized by asset holdings at the beginning of the sample.

1.5 Discussion

In order to understand the drivers behind the empirical results, ultimately what is needed is a multi-country general equilibrium model with a variety of shocks. This goes beyond the current paper. Nonetheless, we can draw on some insights from existing theory of capital flows in DSGE models to put the empirical results into better perspective. We will make some comments on the relative importance of the portfolio growth versus reallocation components in the short-run and the long-run and on the drivers of the portfolio reallocation components.

1.5.1 Portfolio Growth versus Portfolio Reallocation

In the two-country DSGE model with portfolio choice in Tille and van Wincoop (2010a), capital outflows are the sum of a portfolio growth component and a single reallocation component. The latter is associated with the reallocation between Home and Foreign assets. It is shown that this reallocation component depends on changes in expected excess returns and changes the riskyness of the assets.[17] It is not quite as simple as this, as not all drivers of expected returns affect capital flows. Moreover, only changes in the riskyness of assets that affect domestic and foreign investors differentially lead to portfolio reallocation. Without going into further detail though, a couple of comments can be made that connect to our findings.

The first point to make is that in a steady state the reallocation components are

[17] Didier and Lowenkron (2012) provide evidence on the importance of time-varying expected returns for international portfolio reallocation. Evans and Hnatkovska (2014) use a DSGE open economy model with portfolio choice to show that time-varying equity risk premia are a key determinant of international bond and equity flows. Hnatkovska (2010) also develops an open economy DSGE model with portfolio choice to illustrate the role of time-varying risk and expected returns for international capital flows.

all zero. In a steady state there are no changes in expected excess returns and the riskyness of assets (which depend on various second moments). Portfolio growth, on the other hand, will be non-zero in an economy with positive growth as this implies positive net saving. Cumulative capital flows will then be entirely driven by portfolio growth in the long run. This explains the importance of portfolio growth in the long run in all of the four decompositions.[18]

If we had an even longer sample, portfolio growth would dominate the reallocation components even more over the entire sample. Some of the reallocation components have a substantial non-zero mean during our sample. This is due both to the limited length of the sample (20 years) and the fact that the sample covers a period during which the economy was on a transition path towards substantial financial globalization. The share allocated to foreign equity and bonds increased substantially during the sample. This may well continue for another couple of decades, but eventually must end as there is an upper bound to the foreign portfolio share and a related lower bound to international financial frictions (zero). At that point the Home-Foreign reallocation component for both equity and bonds will still fluctuate, but will go back to a mean of zero.

Apart from its non-zero steady state mean, the other reason portfolio growth dominates the reallocation components in the long run is that it is significantly more persistent. This is a feature that we have seen for all decompositions. Theoretically, the portfolio growth component depends on saving, as opposed to the change in saving. By contrast, the reallocation components depend on *changes* in expected excess returns and risk. Saving, expected excess returns and risk in general depend on the

[18]Consistent with our findings, Ahmed et al. (2016) find that persistent flows from the US to emerging markets are driven by portfolio growth, while short-run volatility, such as during the global financial crisis, is associated with portfolio reallocation.

state variables of a model. In Tille and van Wincoop (2010a) the state variables are the wealth and productivity of the two countries. Since productivity is assumed very persistent in their numerical illustration, saving is very persistent as well, consistent with the data. This accounts for the persistence of the portfolio growth component. But while expected excess returns and risk (second moments) depend on these same state variables, Home-Foreign reallocation is not very persistent as the changes in expected excess returns and risk depend on the changes in the state variables.

1.5.2 Drivers of Portfolio Reallocation

The results shed light on the relationship between portfolio reallocation and portfolio rebalancing. The empirical relationship is mixed. There is some relationship at the annual frequency in the first and third decompositions and reallocation tracks rebalancing over the entire sample for the first two decompositions. But in other respects there is little evidence of rebalancing. To understand this, it is useful to realize that in theory this relationship can be anything.

To illustrate this, consider the two-country, two-period portfolio choice model in Davis and van Wincoop (2018). There are four types of shocks: saving shocks (time-discount rate shocks), investment shocks, portfolio shocks and expected asset payoff shocks. Consider the last three shocks (a saving shock is essentially a portfolio growth shock). A shock that raises the relative investment of the Home country raises the relative supply of the Home asset, which lowers the relative price of Home assets. Optimal rebalancing implies buying the Home asset. This is consistent with the actual portfolio reallocation towards the Home asset as the lower relative Home price raises the expected relative return on the Home asset.

However, the other two shocks lead to a negative relationship between portfolio reallocation and rebalancing. Consider portfolio shocks that lead to a reallocation towards Foreign assets. They raise the relative price of Foreign assets, which implies selling Foreign assets for rebalancing purposes. An increase in the expected relative future payoff of Foreign assets has the same effect. Global shocks in the Davis and van Wincoop (2018) model also disconnect portfolio reallocation from rebalancing. In their symmetric two-country setup global shocks, such as for example a global retrenchment towards domestic assets, have no effect on relative prices. Such shocks involve Home-Foreign portfolio reallocation, but there is no need for rebalancing as relative prices have not changed.

Another aspect of our empirical results is that at quarterly and annual frequencies capital flows to individual foreign countries is almost entirely driven by reallocation among different foreign countries. This may be driven by country-specific factors, which for example affect country-specific expected returns and risk. But it may also be the result of global drivers. Specifically, changes in global risk or risk-aversion would lead to a reallocation from foreign countries with risky assets to foreign counties with less risky assets or from foreign countries with a volatile exchange rate relative to the dollar to countries with a less volatile exchange rate. Gourio et al. (2016) develop a model to discuss the impact of changing risk on capital flows. Although their model has only two countries, it illustrates that portfolios are shifted away from the more risky country when there is a global increase in risk.

The importance of global drivers of portfolio allocation among foreign countries is consistent with Sarno et al. (2016). They consider equity and bond flows from the US to 55 countries.[19] They use a latent factor model to decompose these flows

[19] They consider net flows, so US outflows minus US inflows.

into a part associated with a global factor, a part associated with an asset-specific factor (bonds or equity) and a part associated with country-specific factor. Their key finding is that 80% of the variation in bond and equity flows is associated with the first two of these factors, associated with the US and other countries, which they refer to as global economic forces. This connects to a growing literature that has emphasized the importance of global drivers of capital flows.[20]

1.6 Conclusion

We have extended the capital flows decomposition in Tille and van Wincoop (2010a) and applied it to data for equity and bond outflows of the United States. The decomposition is part of a broader decomposition of financial flows (not just capital flows) into portfolio growth and reallocation components. Asset allocation decisions higher up on the decision tree affect financial flows lower down the tree. Specifically, we have seen that equity outflows not only depend on the reallocation between Home and Foreign countries, but also on reallocation between portfolio and non-portfolio assets and between equity and bonds.

Empirical implementation of the decomposition has been facilitated by high quality data on US external equity and bond holdings in various countries. This allows us to compute portfolio shares, which are combined with data on relative asset price changes to obtain reallocation components of capital flows.

Our empirical findings in the previous section relate to the role of the various

[20]Rey (2013) casts this as part of a global financial cycle. Forbes and Warnock (2012) find that global drivers, specifically changes in global risk, are associated with extreme capital flow episodes. Gourio et al. (2016) provide evidence that an increase in global risk reduces capital inflows and outflows of emerging markets.

portfolio reallocation components and the portfolio growth component as drivers of asset purchases. It should be emphasized that these findings apply to one country, the United States, over one particular two decade period. While insightful, we do not know how these results generalize to other countries or sample periods. Nonetheless a number of interesting themes have emerged that should provide guidance to future theoretical work.

Several key conclusions can be drawn from the decompositions. First, portfolio reallocation components are much more important than portfolio growth at quarterly and annual frequencies, while over the entire sample portfolio growth is dominant. Second, portfolio growth is much more persistent than the reallocation components. Third, the relationship between portfolio reallocation and rebalancing is mixed. Finally, a lasting impact of portfolio reallocation to foreign equity/bonds is a significantly larger portfolio growth component. While we have used existing theory to shed some light on these findings, future research should aim to develop a multi-country DSGE model with portfolio choice and a variety of shocks in order to better understand the drivers of the portfolio growth and reallocation components.

Chapter 2

The Cyclical Properties of Disaggregated Capital Flows and Technology Capital

Abstract

We present a model that allows us to examine how technology capital affects the cyclical properties of disaggregated international capital flows. Technology capital is a firm's unique know-how accumulated from investments. We found that technology capital and countries' degree of openness have significant effect on the time evolution of the cyclical behavior of both FDI flows and portfolio flows. The impact on each capital flow component is different. Our findings match data on developed countries from 1975 to 2005.

2.1 Introduction

In recent decades, international capital flows have drawn significant attention as they played an increasingly important role in countries' business cycles. Because gross capital flows are strongly correlated with sudden stops and surges, the increasing size and volatility of capital flows raised concerns regarding countries' financial stability.[1] As a consequence, research on capital flows' cyclicality emerges. The literature started from concentrating on net capital flows' cyclical behavior and then moved to gross capital flows since capital inflows and outflows are likely to be driven by different factors. Very few studies, however, focused on disaggregated capital flows; thus, much less is known about the cyclical properties of different components of capital flows. Also, the time evolution of the cyclicality of capital flows is rarely studied. Understanding the cyclical properties of disaggregated capital flows is potentially important because the behavior of gross capital flows is a mix of all disaggregated flows. The evolution of macroeconomic characteristics might have different influences on the cyclical behaviors of various disaggregated flows.[2] In this paper, we break down gross capital flows into FDI flows and portfolio flows and assess the impact of countries' degree of openness on their cyclical properties.

Among many empirical papers on international capital flows, Contessi et al (2013) is one that studied the relationship between disaggregated gross capital flows and business cycle variables over time. In line with the literature, they found that aggregated capital flows were pro-cyclical from 1970s to 2000s; gross outflows became less pro-cyclical in more recent years. In addition, they documented the dynamics

[1] See Forbes and Warnock (2011).

[2] Based on Flow of Funds definition, disaggregated capital flows refer to: foreign direct investment (FDI) flows, portfolio flows, and debt flows.

of the relationship between disaggregated capital flows and business cycle variables from 1975 to 2005.[3] They found that inward FDI and outward portfolio investment became much more procyclical, while outward FDI became more counter-cyclical. The dynamic of inward portfolio investment cyclicality was not significant. In this paper, we will show that countries' degree of openness to technology capital is able to account for the cyclical dynamics of FDI flows and portfolio flows found in data from 1970s to 2000s. As countries become more (or less) open to foreign technology capital, the cyclical property of each disaggregated capital flow component changes accordingly.

The concept of technology capital was introduced in McGrattan and Prescott (2009) and McGrattan and Prescott (2010). From 1982 to 2006, the returns on investments of foreign subsidiaries of U.S. companies averaged 9.4% while returns on investments of U.S. subsidiaries of foreign multinationals averaged only 3.2%.[4] McGrattan and Prescott (2010) argued that the persistently high return difference was caused by mis-measurement of intangible investments. Most of those intangible investments were investments on technology capital. They showed and estimated the importance of un-measured investments, which distort measured returns on foreign direct investment. Ignoring those intangible investments could pose problems when studying topics related to foreign investments and returns. In this paper, we include both physical capital and technology capital in our model. Both types of capital are necessary and irreplaceable in production. Technology capital is a firm's unique know-how accumulated from investments. It can be used simultaneously in multiple domestic and foreign locations. Examples of technology capital include R&D, brands, reputation,

[3]They consider business cycle variables from three perspectives: output, investment, and real interest rate.

[4]Estimated by the U.S. Bureau of Economic Analysis. See McGrattan and Prescott (2010).

and organizations.

Technology capital is potentially important to the cyclical behaviors of gross capital flows from two perspectives. First of all, it has direct influence on FDI flows. Changing the level of technology capital itself does not cause capital flows. As technology capital can be used in multiple sites simultaneously, however, it can affect the returns on physical capital in different locations. Recent general equilibrium models with portfolio choice have shown that capital flows are largely associated with changes in expected returns and risk characteristics of foreign investment.[5] Technology capital, therefore, has a direct impact on FDI flows by changing the expected return on foreign physical capital investment. In addition, technology capital has an indirect effect on portfolio flows through a spillover effect. If there is no technology capital, country-specific productivity shock cannot be transmitted to other countries. Higher productivity in Home country leads to higher returns on Home assets compared to Foreign assets; pro-cyclical portfolio inflows and counter-cyclical outflows are expected to be observed under such a situation. If we take technology capital into consideration, however, a positive productivity shock in Home country can be spread to other countries through Home subsidiaries from Foreign country. The more open the Home country is, meaning more Foreign technology capital can be used in Home country, the stronger the spillover effect would be. To investors, the return differential between Home and Foreign assets is reduced because of the spillover effect. In other words, Home assets are not as attractive as before. Thus portfolio flows will be affected by countries' degree of openness to technology capital. Notice that mechanisms above can be amplified if there are more foreign countries. In this paper, for simplicity, we consider only one Home country and one Foreign country in the model. In reality,

[5] See Tille and van Wincoop (2010).

where countries normally trade financial assets with many other foreign countries and firms have subsidiaries in multiple foreign locations, technology capital and degree of openness would have a stronger impact on FDI flows and portfolio flows.

The contribution of this paper is twofold. First, we incorporate the concept of unmeasured technology capital into open-economy models with portfolio choice. As McGrattan and Prescott showed, more than 50% of returns on foreign investment is associated with unmeasured technology capital. When studying topics related to foreign assets and returns, for instance, international portfolio choice and capital flows, technology capital should not be ignored. It has not, however, been considered in the literature of international capital flows. We combine portfolio choice theory and technology capital together and connect them to capital flows. Second, we present a model that allows us to assess the influences of technology capital on the time evolution of cyclical properties of disaggregated capital flows. We find that countries' degree of openness to foreign technology capital plays an important role in explaining the cyclical dynamics of disaggregated capital flows over time. Our model prediction on the cyclical dynamics of FDI and portfolio flows matches empirical findings using data from 1975 to 2005. In recent years, as globalization and integration intensified, countries' openness to technology capital became more and more important in explaining the cyclical behavior of international capital flows. Future studies on cyclicality dynamics should not ignore the effect of countries' degree of openness.

The remainder of the paper is organized as follows. In section 2 we describe some empirical results. Section 3 describes a particular model. In section 4, we describe our solution method and test for accuracy. Section 5 describes model results. Section 6 concludes.

2.2 Empirical Facts

In this section, we show some empirical findings regarding capital flows cyclicality in the literature. In the last two decades, people realized that capital inflows and outflows were likely to be driven by different factors. As a consequence, empirical research on cyclical behaviors of capital flows started to analyze gross flows rather than net flows.[6] But most of these studies did not break down capital flows into more disaggregated flows, i.e., FDI flows, portfolio flows, and debt flows. Until recently, researchers began to deal with disaggregated gross capital flows across a diverse set of countries. Contessi et al (2013) is one paper that deconstructs capital flows into Foreign Direct Investment (FDI), Foreign Portfolio Investment (FPI), and Debt flows, and analyzes their various properties separately. Among their many results, the relationship between disaggregated capital flows and business cycle variables over time relates most closely with our study.

The empirical analysis in Contessi et al (2013) covered 22 advanced and emerging economies from 1975 to 2005. They truncate their sample at 2005 to exclude the financial crisis (beginning in 2007) and boom in capital flows leading up to 2007. They collected quarterly time series on disaggregated gross flows and considered the ratio between each flow and GDP. Three macroeconomic variables were examined: the logarithm of GDP, the ratio between gross fixed capital formation and GDP, and the real interest rate. For each transformed macroeconomic variable and capital flow series, they estimated cyclical and trend components using standard filtering techniques.[7] They computed correlations over the 1975 - 1992 period and the 1992 - 2005 period; the change in cyclicality over time can be analyzed. We include some of

[6]See Broner et al (2013); Ersal-Kiziler (2016); Forbes and Warnock (2011).

[7]For details, see Contessi et al (2013).

their results and show them in table 1.[8]

Table 2.1: Correlations with GDP

	FDI inflows	FDI outflows	Portfolio inflows	Portfolio outflows
Panel A. 1975 - 1992				
Countries with positive correlation	71.43%	85.71%	57.14%	14.29%
Average correlation	0.09	0.23	0.05	-0.13
Sign	+	+	?/+	+
Panel B. 1992 - 2005				
Countries with positive correlation	84.61%	53.85%	61.54%	46.15%
Average correlation	0.16	-0.01	0.04	-0.05
Sign	+	-	+	+
Panel C. Change				
Countries with positive correlation	13.18%	-31.86%	4.4%	31.86%
Average correlation	0.07	-0.24	-0.01	0.08

Notes: we report + (or -) if there are significant correlations and the majority of them are positive (or negative); we report ?/+ (or ?/-) if the number of significantly positive correlations is the same as the number of significantly negative correlations and the majority of the non-significant correlations are positive (or negative); (c) we report ? in all other cases.

We pay particular attention to the changes in cyclical behaviors of each capital flow component over the two periods. In panel 3, we can see that FDI inflows and portfolio outflows became more positively correlated with real GDP growth rate from all perspectives (average correlation and percentage of positive countries). In the meantime, FDI outflows became less correlated with the growth rate of real GDP. For portfolio inflows, two different measurements give us different results: a bigger portion of countries have positive correlations in later decades, while the average correlation value decreases. Notice that the changes in both estimates are relatively

[8] We only consider Contessi et al (2013)'s results regarding advanced countries. Disaggregated capital flows data for emerging countries before 1992 are not complete.

close to zero, suggesting that the correlation between real GDP growth rate and portfolio inflows did not change significantly over the two periods.

Overall, we can conclude that: from 1975 to 2005, for advanced economies,

- *FDI inflows become more procyclical.*
- *FDI outflows become less procyclical.*
- *Portfolio inflows' cyclicality does not change a lot; the direction of the change is unclear.*
- *Portfolio outflows become more procyclical.*

Appendix 1 shows the correlation for each G-7 country. Notice that we cannot tell whether the result in Contessi et al. (2013) is driven by country-specific shock or global shock. This is potentially important to our model because in the model, country-specific shock is the major driver of various cyclical dynamics of capital flows. We therefore conduct similar analysis to check whether the cyclical property of each capital flow component still holds if we eliminate global shocks. Specifically, instead of examining the correlation between each country's real GDP growth rate and capital flows, we consider country's real GDP growth rate less the world real GDP growth rate. The data come from the analytic presentation of the IMF's Balance of Payments Statistics Yearbook (BOP) and OECD Economic Outlook. Like in table 1 panel 3, we calculate the difference in the average correlation and the percentage of countries with positive correlations:

The cyclical pattern of disaggregated capital flows from 1975 to 2005 remains the same. In addition, after eliminating global shocks, we have a clear pattern in the

Table 2.2: Changes in Correlations from 1975 to 2005

	iFDI	oFDI	iFPI	oFPI
Countries with positive correlation	16.67%	-25.00%	-25.00%	8.33%
Average correlation	0.15	-0.14	-0.21	0.14

cyclical behavior of portfolio inflows over time: they become less procyclical.

Overall, the significant heterogeneity in the cyclical dynamics above suggests that the time evolution of some macroeconomic characteristics might have different impacts on different components of capital flows. In the next section, we present an open economy portfolio choice model with technology capital that is able to account for those empirical findings above. We show that the evolution of countries' degree of openness to technology capital is the key to understanding the cyclical dynamics of each disaggregated capital flow component.

2.3 Model

We consider a world economy consisting of two identical countries. Country-specific variables are indexed with the superscript $i \in \{H, F\}$, where H is the home country and F is foreign. Each country is populated by a continuum of identical households who supply their labor inelastically to domestic and foreign firms. Both domestic and foreign firms are perfectly competitive, and issue equity that is traded among all home and foreign households. The model is designed to study how a country's degree of openness affects the cyclicality behavior of disaggregated capital flows.

The model features two types of capital stocks: technology capital and physical capital. Technology capital is accumulated know-how from intangible investments in R&D, brands, and organizations, all of which can be used in foreign and domestic locations simultaneously. Examples of technology capital include brands, reputaion, popularity, and R&D. We assume that firms invest technology capital only at their headquarters and that it can be used by all foreign locations with no additional cost.[9] Physical capital is firm- and location-specific, and must be invested in the associated production site. There is an adjustment cost associated with physical capital investment, which prevents firms from frequently moving physical capital stocks across countries.

2.3.1 Production

There is one firm in Home country and one in Foreign country. Each firm owns its own technology capital and physical capital. Firms issue equity in the world stock market. The firm from country i can operate in both countries. The production of firm i operating in country j at time t can be expressed as:

$$Y_t^{i,j} = A_t^j(\sigma^{i,j} M_t^i)^{\phi_1}[(K_t^{i,j})^{\nu}(N_t^{j,i})^{1-\nu}]^{1-\phi_1}; i, j \in \{H, F\} \tag{2.1}$$

where A_t^j is j's country-specific exogenous state of productivity; M_t^i is the technology capital level of the firm from country i; $K_t^{i,j}$ is the physical capital level for firm i in country j; $N_t^{i,j}$ is the labor input for firm i in country j. We assume inelastic labor supply in each production site, and it is fixed at 1. The production function can then

[9] The only friction that prevents foreign production sites from using the technology capital is foreign country's degree of openness. We will describe how the degree of openness works in details later.

be written as:

$$Y_t^{i,j} = A_t^j(\sigma^{i,j} M_t^i)^{\phi_1}(K_t^{i,j})^{\phi_2} \tag{2.2}$$

where $\phi_2 = \nu(1-\phi_1)$. $\sigma^{i,j}$ stands for country j's degree of openness to country i. It measures the degree to which foreign firm's technology capital is allowed to be used in production by foreign firm at home country. If country j is completely closed, only domestic firm operates in home country, then the openness parameter is zero. If country j is completely open, $\sigma^{i,j}$=1. In general, if $i = j$, $\sigma^{i,j} = 1$; If $i \neq j$, $0 \leq \sigma^{i,j} \leq 1$. The goods produced by Home and Foreign firms are identical and can be transported between countries without costs.

The country-specific productivity process follows:

$$A_t^i = \rho A_{t-1}^i + \epsilon_t^i,\ \epsilon_t^i \sim \mathcal{N}(0, \sigma_{i,t}^2) \tag{2.3}$$

2.3.2 Firm's Problem

At the beginning of each period, firms observe the current state of productivity and capital level, and then make their investment decision on both physical capital and technology capital. Each firm's profit equals to the firm's production from both locations, less investment expenditure in physical and technology capital. A portion τ of a firm's profit will be transferred to domestic households. This is like a proportional tax levied on domestic firm and will be collected by domestic households. The rest of the firm's profit will be used to finance dividend payments to the owners of the firm's equity. Home firm's dividend can be written as:

$$D_t^H = \Big\{ Y_t^{H,H} + Y_t^{H,F} - \big[M_{t+1}^H - (1-\delta_M) M_t^H\big] \\ - (q_{n,t}^{H,H} K_{t+1}^{H,H} - q_{o,t}^{H,H} K_t^{H,H}) - (q_{n,t}^{H,F} K_{t+1}^{H,F} - q_{o,t}^{H,F} K_t^{H,F}) \Big\} (1-\tau) \tag{2.4}$$

Notice that the firm can use its technology capial, M_t^H, in multiple locations; so M_t^i is not indexed by the operation location j.

Analogously, foreign firm dividend is:

$$D_t^F = \Big\{ Y_t^{F,H} + Y_t^{F,F} - \big[M_{t+1}^F - (1-\delta_M) M_t^F\big] \\ - (q_{n,t}^{F,H} K_{t+1}^{F,H} - q_{o,t}^{F,H} K_t^{F,H}) - (q_{n,t}^{F,F} K_{t+1}^{F,F} - q_{o,t}^{F,F} K_t^{F,F}) \Big\} (1-\tau) \tag{2.5}$$

Physical capital is supplied by competitive installment firms. In each period, installment firms purchase old physical capital from production firms at price $q_{o,t}^{i,j}$ and sell new physical capital (for next period's production) at price $q_{n,t}^{i,j}$. Competitive installment firms maximize their profit as:

$$q_{n,t}^{i,j} K_{t+1}^{i,j} - q_{o,t}^{i,j} K_t^{i,j} - I_t^{i,j} \tag{2.6}$$

such that

$$K_{t+1}^{i,j} = (1-\delta) K_t^{i,j} + \Phi(\frac{I_t^{i,j}}{K_t^{i,j}}) K_t^{i,j} \tag{2.7}$$

where

$$\Phi(\frac{I_t^{i,j}}{K_t^{i,j}}) = \frac{a_1}{1-\frac{1}{\xi}} (\frac{I_t^{i,j}}{K_t^{i,j}})^{1-\frac{1}{\xi}} + a_2 \tag{2.8}$$

Home and Foreign production firms maximize the value of the firm to its shareholders. The optimization problem for firm i is:

$$\max E_t \sum_{s=t}^{\infty} Z^i_{t+s,t} D^i_{t+s} \tag{2.9}$$

subject to equation 4 and 5. Z^i_t is country i's household's intertemporal marginal rate of substitution (IMRS) between consumption in period $t+s$ and t. We assume that firm in each country uses the stochastic discount factor of domestic households to value the firm.

2.3.3 Households

Countries are populated by a continuum of households that have identical preferences. Households in country i maximize their expected present discounted utility by solving the following optimization problem:

$$\max E_t \sum_{s=0}^{\infty} \beta^s U(C^i_{t+s}) \tag{2.10}$$

Households can hold domestic equity and equity issued by foreign country.[10] Households receive a transfer from domestic firm each period. The household budget con-

[10]A risk-free international bond can also be included in the model. Right now we only consider equity trading. Adding bond trading will be the next step of the paper.

straint can be written as:

$$C_t^i + Q_t^i X_{t+1}^{i,i} + Q_t^j X_{t+1}^{i,j} \leq (D_t^i + Q_t^j) X_t^{i,i} + (D_t^j + Q_t^j) X_t^{i,j} + T_t^i \tag{2.11}$$

where Q_t^i stands for the equity price of country i's firm; $X_t^{i,j}$ stands for country i households' holdings of country j firm; T_t^i is the transfer payment from domestic firm.

2.3.4 Market clearing conditions

The market clearing condition for goods requires that the world demand for consumption goods equal world output, less the amount allocated to investment on both physical and technology capital:

$$Y_t^{i,i} + Y_t^{i,j} + Y_t^{j,i} + Y_t^{j,j} = C_t^i + C_t^j + I_t^{i,i} + I_t^{i,j} + I_t^{j,i} + I_t^{j,j} + I_{M,t}^i + I_{M,t}^j$$

We normalized the number of outstanding shares issued by Home and Foreign firms to unity. So for asset market:

$$X_t^{i,i} + X_t^{j,i} = 1; i, j \in \{H, F\}$$

2.3.5 Market completeness

Market incompleteness is very important in analyzing international capital flows. If the market is complete, only net flows matter; gross capital flows can take different values without affecting the real allocations of the world economy. Since our model does not feature any element of asymmetry (like home bias, information asymmetry) or friction (like iceberg cost), it is important to ensure the market is incomplete in our model. In fact, the market is complete only when the following condition is satisfied: $\gamma = 1/\theta$, where γ is the coefficient of relative risk aversion in household's preference, and θ is consumers' elasticity of substitution between domestic and foreign goods. In our model, since we do not distinguish between Home and Foreign good, the elasticity of substitution is infinity. Therefore, the model is complete only when γ is equal to zero. The detailed proof of the above conditions can be found in Obstfeld and Rogoff (1996, Section 5.3). Basically, if $\gamma \neq 1/\theta$, the transfer from domestic firm to domestic households causes people in different countries to choose different portfolios of risky assets. Under this situation, Pareto efficiency can be ensured only when the number of states of nature is no greater than the number of countries plus 1. In general, spanning requires as many independent assets as states of nature. In our model, the spanning condition is clearly violated.[11] Even though the correlation between their consumption series could be high, risks cannot be perfectly shared across Home and Foreign households. Gross capital flows can be pinned down uniquely in our model.

2.4 Method Solution

2.4.1 Solution algorithm

Standard linearization method cannot handle portfolio choice problems. We employ the numerical algorithm described by Heathcote and Perri (2013). Their algorithm can be used to solve for equilibria in general international macro models with portfolio

[11] For details and proofs, see Obstfeld and Rogoff (1996) Appendix 5A. Even though the spanning condition is violated, market could be seen as complete when we only consider first order approximation. However, as we will mention below, we adapt a higher order approach, which ensures that our solution is based on an incomplete market setting.

choice. The detailed steps of the algorithm is outlined in below.

Step 1: We start from picking a non-stochastic symmetric steady state equilibrium. We denote such a steady state with the vector $[X, X^*, Z, Y]$, where X and X^* are the fractions of shares of local firm held by home and foreign agents, respectively; Z is the vector of non-portfolio state variables (i.e., productivities, physical capital stocks, and technology capital stocks); Y is the vector of non-portfolio control variables (i.e., consumption, investment, capital price). First order conditions plus symmetry uniquely pin down Z and Y, while any value $X_0 = X = X^*$ is a non-stochastic symmetric steady state equilibrium.

Step 2: We compute decision rules $X_{t+1} = g_1(X_t, X_t^*, Z_t)$, $X_{t+1}^* = g_2(X_t, X_t^*, Z_t)$, $Z_{t+1} = g_3(X_t, X_t^*, Z_t)$, $Y_t^* = g_4(X_t, X_t^*, Z_t)$. These decision rules characterize the solution to a third-order approximation of the stochastic economy around the steady state from step 1. The functions g_1, g_2, g_3, and g_4 can be computed using the method described by Schmitt-Grohe and Uribe (2004). We use Dynare (version 4.5.3) to run the third-order approximation and estimate those decision rules. Notice that, as described in Heathcote and Perri (2013), to implement the higher order approximation here, it is necessary to slightly modify the model by adding a small adjustment cost for changing the portfolio from its steady state value. We add a tiny quadratic adjustment cost to households' budget constraint if they deviate from the steady state portfolio allocation. Those functions (g_1 to g_4) give us the correct decision rules (including portfolio decisions) up to a third-order approximation. We still do not know, however, if the initial steady state portfolio X_0 is equal to the true stochastic economy portfolio allocation.

Step 3: Using the initial steady state portfolio X_0 from Step 1 and decision rules g_1 through g_4 from Step 2, we simulate the model economy for a large number of periods ($T = 100,000$). We compute the average share of wealth held by domestic and foreign agents along the simulation. If this average share is different from the initial steady state share, we set the new guess for the steady state portfolio, X_1, equal to the average simulated share and return to Step 1. If the simulated average is equal to the initial steady state share, X_0 constitutes a good approximation of the long run portfolio allocation and we take it as the solution to our portfolio problem.

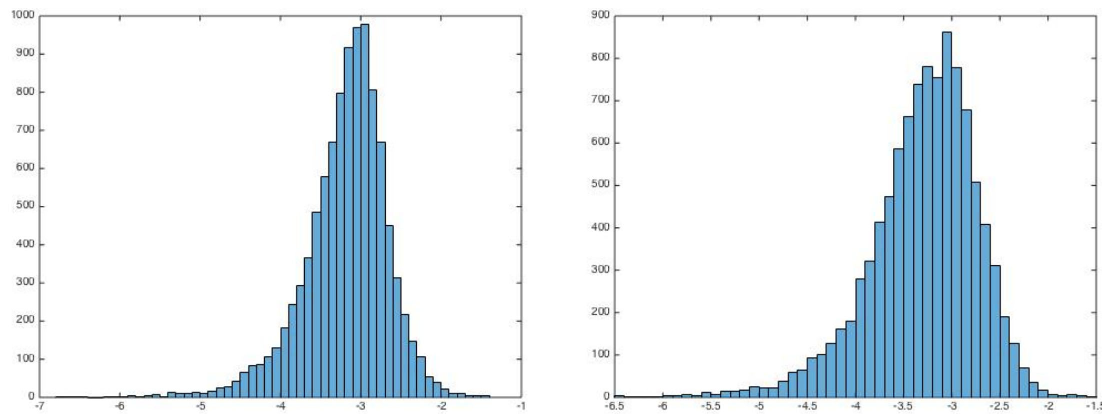
2.4.2 Accuracy test

To validate our solution method, following Judd (1992), we compute the Euler equation errors to check on the accuracy of our solution method. Moving from the Euler equation for consumption, we define the Euler equation error as a fraction of units of consumption, and express it in decimal log scale. For country i, the consumption Euler equation error can be represented as:

$$\text{error}_t^i = log_{10}\left|1 - \frac{U'^{-1}\left[\beta \mathbb{E}_t[U'(C_{t+1}^i)]R_{t+1}^i\right]}{C_t^i}\right|$$

To estimate the equation above, we use Gauss-Hermite quadrature to approximate $\mathbb{E}_t[U'(C_{t+1}^i)]$; C_t^i and R_{t+1}^i are calculated from decision rules found in section section 4.1. We simulate the model economy for 10,000 periods. For each period, we calculate the consumption Euler equation errors for both Home and Foreign countries. Figure below shows the histogram of them. The error is reasonably small; the average error for Home consumption is -3.1854 and the average error for Foreign consumption is -3.2958. To interpret that, a value of -3 under the decimal log scale means that the error is sized at \$1 per \$1000 of consumption.

Figure 2.1: Histogram of consumption Euler equation errors in model simulation



(a) Home country consumption (b) Foreign country consumption

2.5 Result

We investigate the relationship between FDI outflows, FDI inflows, portfolio outflows, portfolio inflows and GDP growth rate under different values of openness parameter, $\sigma^{i,j}$. All disaggregated capital flows are normalized by GDP from the current period. Since our model consider multinationals and international asset tradings, one key question is how to measure capital flows. For example, if foreign households buy shares of home firm that also operates in foreign country, is this purchase counted as capital inflows to Home country? If yes, is the entire purchase counted as Home country inflows or just a part of the purchase? According to the international statistical framework, the key concept in measuring international asset trading is that of residence. Residence is a legal concept denoting the relationship between an entity and a location. It is clear-cut; each institutional unit is a resident of only one economic territory.[12] For a firm, residence is defined as the economic territory with which it has the strongest connection, expressed as its centre of predominant economic interest, or the location of its headquarter. A firm resident on island A can operate and produce elsewhere. For example, it could enter a contract manufacturing agreement with island B, and sell the output in island C. The good is shipped from B to C, and never touches the shores of island A. Any purchase of firm As share would nevertheless be counted as capital flows toward island A. Island As capital inflows would go up.[13] Mathematically, according to the residence-based approach, we can express each disaggregated capital flow component for country i at time t as:

$$
\begin{aligned}
\text{FDI inflows} &= q^{j,i}_{n,t} K^{j,i}_{t+1} - q^{j,i}_{o,t} K^{j,i}_{t} \\
\text{FDI outflows} &= q^{i,j}_{n,t} K^{i,j}_{t+1} - q^{i,j}_{o,t} K^{i,j}_{t} \\
\text{Portfolio inflows} &= Q^{i}_{t} (X^{j,i}_{t+1} - X^{j,i}_{t}) \\
\text{Portfolio outflows} &= Q^{j}_{t} (X^{i,j}_{t+1} - X^{i,j}_{t})
\end{aligned}
$$

GDP of country i equals to firm i's production in country i plus firm j's production in country i. We simulate the world economy using the decision rules found in the previous section. We calculate different components of capital flows by the above equations and their correlations with GDP growth rate. Table below shows the correlations under different values of the degree of openness parameter. Notice that our focus is on how correlations would change under different $\sigma^{i,j}$, not the correlation value itself. In other words, we concentrate on whether the correlation between capi-

[12] An institutional unit is defined as households, corporations, non- profit institutions, government units, legal or social entities recognised by law or society, or other entities that may own or control them.

[13] For details, see Avdjiev et al (2018, BIS) and IMF (2009, p 70).

tal flow component and GDP growth rate increases or decreases when we change $\sigma^{i,j}$ parameter.

Table 2.3: Correlations with GDP under Different Openness Parameters (Model)

Correlation Values				
$\sigma^{i,j}$	**FDI inflows**	**FDI outflows**	**Portfolio inflows**	**Portfolio outflows**
0.1	-0.0445	-0.0748	0.2589	-0.2017
0.3	0.5178	-0.5121	0.1441	0.3225
0.5	0.6454	-0.6010	0.0752	0.5108
0.7	0.6831	-0.6320	0.0217	0.6210
0.9	0.6973	-0.6461	0.0015	0.6600
Changes in Correlations				
$\sigma^{i,j}$	**FDI inflows**	**FDI outflows**	**Portfolio inflows**	**Portfolio outflows**
0.1 to 0.3	0.5623	-0.4373	-0.1148	0.5242
0.3 to 0.5	0.1276	-0.0889	-0.0689	0.1883
0.5 to 0.7	0.0377	-0.0310	-0.0535	0.1102
0.7 to 0.9	0.0142	-0.0141	-0.0202	0.0390
Total	0.7418	-0.5713	-0.2574	0.8617

We pay particular attention to the lower panel in the table: changes in correlations when we increase the value of the degree of openness parameter. The model predicts that, as countries become more open,

- FDI inflows become more procyclical.
- FDI outflows become less procyclical.
- Portfolio inflows become a little less procyclical. The size of the change is relatively small compared to other capital flow components.
- portfolio outflows become more procyclical.

2.5.1 FDI Inflows

The model predicts that as countries become more open to foreign technology capital, FDI inflows become more correlated with GDP growth rate. Especially, when the degree of openness is low, its impact on the cyclical behavior of FDI inflows is more significant. This finding matches the empirical result regarding FDI inflows in Section 2. In recent decades, due to globalization and integration, barriers like information asymmetry, which prevents technology capital from being used globally, have been gradually removed. This lowering of barriers leads to a higher value of openness parameter, $\sigma^{i,j}$. Our model says that the increase in openness to foreign technology capital leads to greater pro-cyclicality in FDI inflows. To see this, imagine a positive TFP shock in Home country. Higher productivity in Home country would attract foreign investment to Home country and cause procyclical FDI inflows, regardless of how open Home country is, if not completely closed. With a higher degree of openness in Home country, more foreign technology capital is allowed to be used in production and, in turn, makes foreign physical capital at Home country, $k_t^{j,i}$, more productive. Foreign firms therefore would like to invest even more physical capital in Home country because of the productivity increase. As a consequence, FDI inflows are more procyclical as $k_t^{j,i}$ is more productive when the degree of openness is higher. In fact, the investment in technology capital should also be procyclical and the correlation with GDP should be increasing as we increase degree of openness.[14] Since technology capital just needs to be invested in one location (headquarter) and can be used simultaneously in multiple sites, investing in M_t^i does not affect capital flows.

[14]We have checked the correlation between $M_{t+1}^i - (1-\delta_M)M_t^i$ and real GDP growth rate under different values of openness. The correlation is higher when the degree of openness becomes larger.

2.5.2 FDI Outflows

Our model suggests that the correlation between FDI outflows and GDP growth rate decreases as we increase the value of the openness parameter. This result accords to data, where we see significant drop in countries' average correlation and percentage of countries with positive correlation from 1975 to 2005. In fact, when we consider cyclicality behavior, FDI outflows behave just the opposite way as FDI inflows. This is because Home FDI outflows can be seen as Foreign FDI inflows, and a positive Home productivity shock can be seen as a negative productivity shock in Foreign country. We know that when countries become more open, Foreign FDI inflows are more correlated with Foreign productivity. In other words, Home FDI outflows would be less correlated with Home productivity, or more counter-cyclical, when degree of openness increases.

Notice that the model shows negative correlations between FDI outflows and GDP growth rate under all degrees of openness, while we see positive correlations from data. We do not claim that our model matches those correlations successfully. In fact, for advanced economy, a significant amount of FDI outflows go to developing economies.[15] To match the actual correlation value from data, we need to introduce asymmetry into the model. For this paper, our goal is to catch the change of cyclicality if we were to change the degree of openness.

2.5.3 Portfolio Inflows

Another important component in gross capital flows are portfolio flows. Different from FDI flows, which are physical investments made by firms for production purposes,

[15] See Jackson (2017).

portfolio flows are asset (ownership of firms) tradings among investors for speculating and hedging purposes. In Contessi et al (2013), we do not find a clear cyclical pattern of portfolio inflows over time: a bigger portion of countries shows positive correlation in recent years, but the average correlation decreases. Changes in percentage and average correlation are relatively small (4.4% and -0.01), fairly close to zero. We interpret the empirical fact as: there is no significant change in cyclical behaviors of portfolio inflows from 1975 to 2005; if there is, the direction of the change is unclear to us.

Regarding this change issue, our model predicts that the correlation between portfolio inflows and real GDP growth rate decreases as the openness parameter becomes larger. The drop in correlation, however, is relatively small, compared to changes in other three capital flows components. When we increase the openness parameter from 0.1 to 0.9, the change in correlation for portfolio inflows is -0.2574, while for the other three components, the number is 0.7418, -0.7284, and 1.1864. Overall, the model suggests that portfolio inflows become less procyclical when countries become more open; but the drop in correlation is small.

To connect our model prediction to empirical findings in section 2, our explanation is that: since the cyclical dynamics of portfolio inflows is not obvious, given the data quality that Contessi et al (2013) used, the decrease in correlation over time can hardly be observed empirically. Therefore, the change in portfolio inflow cyclicality in their paper is unclear and close to zero.

2.5.4 Portfolio Outflows

Portfolio outflows are buying or selling of shares of foreign firms. As more foreign technology capital is allowed to be used in domestic country, portfolio outflows are more correlated with the growth rate of domestic GDP. This is suggested by both our model and the empirical analysis from 1975 and 2005. The impact of degree of openness on portfolio outflows is due to a productivity spillover effect. Suppose there is a positive TFP shock in Home country, with technology capital, foreign firms also benefit from high Home productivity shock because they can operate in Home country. When degree of openness is larger, the spillover effect is stronger and thus the return on foreign firm's investment in Home country is higher. As a whole, foreign firm is more productive under high degree of openness, and the return on owning foreign firm is higher. Home assets are not as attractive as before. Investors would love to hold more shares of foreign firm in their portfolio when countries are more open, leading to a more procyclical portfolio outflows.

2.6 Conclusion

This paper uses technology capital (i.e., R&D, brand, reputation) and countries' degree of openness to account for the cyclical dynamics of FDI flows and portfolio flows over the last three decades. The concept of technology capital was introduced in McGrattan and Prescott (2009), where they showed the danger in failing to consider intangible capital, like technology capital, in estimating returns on foreign investment. Our model combines technology capital and portfolio choice theory. We show that, due to the unique property of technology capital (it can be used in multiple production locations simultaneously), changing countries' degree of openness to technology capital has significant impact on the cyclical property of capital flows. In addition, the influence of the degree of openness on each capital flow component is very different. Specifically, if we were to increase countries' openness parameter, FDI inflows and portfolio outflows would become more procyclical, while FDI outflows would become less procyclical; portfolio inflows also would become less procyclical, with much smaller magnitude. Our findings match empirical results in Contessi et al (2013), where they use quarterly data collected from advanced economies from 1975 to 2005 to analyze various properties of disaggregated capital flows.

We show that technology capital and countries' degree of openness have significant influence on the cyclical behavior of disaggregated capital flows. In recent years, technology capital became more and more important to both production firms and households. Firms rely more heavily on patent and R&D in their production; households now pay more attention to brands and reputation when choosing products. At the same time, as globalization and integration intensified, countries became more open in every aspect, including foreign intangible capital. Barriers that prevent foreign technology capital from being used in domestic country have been gradually removed, especially in developed economies. Overall, all these factors together give technology capital a more important role in explaining the cyclical property of international capital flows. In future studies, researchers should not ignore the effect of technology capital and degree of openness when analyzing cyclical behaviors of disaggregated international capital flows.

Appendix

Real GDP Growth Rate and Capital Flows Correlations (G-7 Countries)

	FDI Inflows	FDI Outflows	Portfolio Inflows	Portfolio Outflows
Panel A. 1975 - 1992				
Canada	0.09	0.24	-0.01	-0.25
France	0.08	0.37	0.07	-0.13
Germany	0.06	0.01	-0.07	-0.15
Italy	-0.05	0.23	0.11	0.13
Japan	-0.00	0.37	0.30	-0.26
UK	0.17	0.31	0.07	-0.12
USA	0.17	0.35	0.23	-0.11
Average	0.07	0.27	0.10	-0.13
Panel B. 1992 - 2005				
Canada	0.21	0.11	0.04	0.27
France	0.15	0.37	0.24	0.06
Germany	0.16	0.03	0.02	0.27
Italy	0.21	0.03	0.04	0.04
Japan	-0.02	0.07	-0.12	-0.26
UK	0.11	0.07	-0.03	0.02
USA	0.48	-0.01	0.20	0.14
Average	0.19	0.09	0.05	0.08
Panel C. Change				
Canada	0.12	-0.13	0.05	0.52
France	0.07	0.00	0.17	0.19
Germany	0.10	0.02	0.09	0.42
Italy	0.26	-0.20	-0.07	-0.09
Japan	-0.02	-0.30	-0.42	0.00
UK	-0.06	-0.24	-0.10	0.14
USA	0.31	-0.36	-0.03	0.25
Average	0.12	-0.18	-0.05	0.21

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